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WILLIS STANLEY BLATCHLEY

Willis Stanley Blatchley was born October 6, 1859, in the New England town of North Madison, in Connecticut, and died at Indianapolis, Indiana, May 28, 1940.

Blatchley was an individualist. He depended on no one but himself for his thoughts and ideas and was uninfluenced excepting by concrete information which was clearly and effectively given. This characteristic is shown in his thoughtfulness in publishing his own life history, bibliography, and other information of value to future scientists in "Blatchleyana," 1930, and "Blatchleyana II," 1940. This complete bibliography of his life and scientific findings leaves little for us to add, excepting our personal observations and interpretations as a result of 20 years of close contact.

Though Blatchley was born in Connecticut, he was in reality a Hoosier, for his parents moved to Indiana in 1860, the year after his birth. During his high school days at Bainbridge in central Indiana, he assisted his father in market gardening. At 18 he earned his first money peddling notions in Putnam and adjoining counties. In 1878, after attending a six weeks summer term at the Danville Normal School, he obtained a license to teach, but failing to secure a teaching position he continued peddling notions. He secured his first teaching position in 1879, and continued in this occupation, along with money making side lines, until the fall of 1883 when he entered Indiana University. Few have had the opportunity of studying under and with a more distinguished group of scientists, or have gained more enthusiasm and knowledge through these associations, than did Blatchley. It was his privilege to study under such eminent scientists as David Starr Jordan, Charles H. Gilbert, John C. Branner, Barton W. Evermann, Carl H. Eigenmann and Oliver P. Jenkins. His interest in the natural

sciences which was aroused by these associations, with his genuine love for Nature in its broadest aspects, his keen memory, and his untiring energy, were doubtless the chief factors contributing to his success as a scientist.

For the first seven years following his graduation from Indiana University, 1887–1894, Blatchley was head of the Department of Science of Wiley High School in Terre Haute. There he taught a variety of subjects including chemistry, botany, zoology, physiology, physical geography, and physics.

On the urgent request and recommendations of those who recognized his scientific achievements and abilities, he was nominated and elected to the position of State Geologist of Indiana in 1894, which position he held with unusual distinction for 16 years. When defeated for re-election in the Democratic landslide of 1911, he retired from official life.

The years from 1911 to his death may be spoken of as the years of his retirement, but only insofar as it refers to his official life. He must have enjoyed those last 29 years immensely. He was living with Nature. He did what he enjoyed and enjoyed what he did. His days and nights were fully occupied with the studies which meant so much to him and which will mean even more to humanity in years to come. Although primarily recognized internationally as an entomologist, his interests were much diversified as evidenced by the publication on such subjects as fishes, weeds, and nature in general. He enjoyed most his trips through the fields and woods. His memory was remarkable, and I doubt if he ever forgot observations he made during his active life. I recall a trip with him some eight or ten years ago to the Wyandotte Cave region where he had collected some 15 or 20 years before. As we would go to this or that place where he had collected before, he would often remark, "Here is where I took 'such and such a species,' and we should find more of the same species," and sure enough we would.

Blatchley was a prolific writer, being the author of 250 publications, many of which were of book size and at least two of them well over 1,000 pages each. His nature publications and his entomological manuals, together with his volumes of reports as State Geologist of Indiana, are his publications which are best known to the scientists of the world.

During his life Blatchley received many well deserved honors. To me the one outstanding honor and perhaps the one he appreciated most was the acknowledgment of his record as a

naturalist by the well-known Hamilton County Nature Study Club in dedicating itself to him by giving that club his name. He was one of the few honorary fellows of the Entomological Society of America and the Indiana Academy of Science, and a fellow of the Geological Society of America. He was president of the Indiana Academy of Science in 1903 and occupied the same office in the State Geologists' Association of the Mississippi Valley in 1908. He was the first president of the Indiana Conservation Congress in 1911. In 1921 his alma mater conferred upon him the honorary degree of Doctor of Laws.

As I look back over the 20 years of close association with Blatchley, I visualize him as a leader in many fields of Science and Humanity. I see him as the Naturalist, the Entomologist, the Geologist, the Wit, and the Philosopher.

Blatchley the Naturalist. Blatchley was a true naturalist. He enjoyed and loved not plants alone, insects alone, or fishes alone; rather he loved Nature in its entire complex. He was a keen observer who recognized the interrelations of all things in Nature, and was able to interpret and write simply of things which are so complicated to most of us.

Perhaps Blatchley is best known for his achievements in Entomology, but in my opinion he was greatest as a naturalist, for he was interested in all Nature.

Blatchley the Entomologist. His first comprehensive taxonomic paper dealing with insects was published in 1903 in the 27th Annual Report of the Indiana Department of Geology and Natural Resources under the title "The Orthoptera of Indiana." His well-known treatise "The Coleoptera or Beetles Known to Occur in Indiana," consisting of 1386 pages and 595 text figures, was published in 1910, and was perhaps his most valued contribution to Entomology. It gave us a complete and popular account of the largest order of insects and in a language understandable to all. In 1916, in collaboration with Charles W. Leng, he published the "Rhynchophora or Weevils of Northeastern America." Four years later he published the "Orthoptera of Northeastern America." The last of his insect manuals was published in 1926. This was the complete taxonomic study of the "Heteroptera or True Bugs of Eastern North America."

These exhaustive treatises are standards and monuments to one who did much to popularize insect taxonomy. His achievements in this field were perhaps all the more outstanding

because he was without the facilities of an institutional collection or library and because he wrote in a language understandable to all entomologists and not alone to the highly skilled taxonomists.

Blatchley described 14 new genera and 472 new species in the orders Coleoptera, Hemiptera and Orthoptera. His collections, now permanently housed at Purdue University, contain 470 of his types.

Blatchley the Geologist. For 16 years Blatchley was State Geologist of Indiana and during these years accomplished more in making known the natural resources of Indiana than any man before or since. When he entered office in 1894 he foresaw the importance and possibilities of the vast resources of Indiana and recognized the opportunity of serving the citizens of his state. Thus, he surveyed and studied these natural resources and in the 16 volumes of some 15,000 pages, which he issued during his tenure in office, he published the results of these studies. They included a great variety of subjects including the clays and clay industries, the shale and marl deposits, the caves, petroleum and coal resources, building stones, including also those of importance in the lime and cement industries, mineral waters and road materials. Perhaps we might speak of Blatchley as the "father" of good roads in Indiana, for so far as I can learn he was the first to give serious consideration to the importance of good roads and the road materials available within the state.

Blatchley the Wit. I first gave as one characterization "Blatchley the Humorist." But according to the dictionary a humorist is "one subject to humors or whims, which he indulges in whimsical ways." Then on looking up the definition of wit I found that this term refers to "mental alertness; especially such capacity along with lively fancy and aptness or talent for clever expression," and again, "a person quick in perception or felicitous and amusing associations of ideas or words and apt in expressing them." Finally I found a comparison of the meaning of the two words, wit and humor, as follows: "Wit is more purely intellectual than humor." And so I realized the better statement should read, "Blatchley the Wit," for throughout his books, especially his nature books, we find the keen wit of Blatchley. To those who had the privilege of knowing him intimately this was also evident in conversation.

Blatchley the Philosopher. Throughout his life and writings we see Blatchley as a philosopher, that is, "one who meets or regards all vicissitudes with calm." The following two paragraphs taken from "Blatchleyana II" under "Some of My Beliefs," give his philosophy of life.

"I believe in Tolerance: that the only true measure of a man is to be judged by his moral character, his willingness to at all times abide by the Golden Rule and the laws of his country and his desire and ability to do what he can whenever he can to advance the moral and material prosperity of his fellow man. A man's creed—no other man should question—the color of his skin no man can control; hence here in America, the so-called Land of the Free—Jew and Gentile, Catholic and Protestant, Negro and Chinaman—should stand equal before the law and in the eyes of his fellow man.

"I believe in the Universal Brotherhood of Man, a brotherhood that should stand for equality and justice throughout the World. I believe that any religion which is based upon this Brotherhood of Man and the practice of the Golden Rule—'Do Unto Others as you Would that They Should Do Unto You'—is a great aid in the advancement of morality and character of the citizen of any nation."

All I have said might be summarized in the citation at the time Doctor Blatchley received his LL. D. degree from Indiana University, which reads:

"Willis Stanley Blatchley, native of Connecticut; educated in the Schools of Indiana; successful teacher; leader in expeditions of scientific explorations; sixteen years an efficient officer of the State in the capacity of State Geologist; a life-long student of natural history, author of literary and scientific works; a nation-wide authority on beetles, weevils and locusts; one of the foremost naturalists of America; interpreter of Nature's beauty in woodland and meadow, by wayside and stream, in stones and in flowers."

J. J. Davis.

REMARKS ON THE GENUS CORIZUS OF AUTHORS, NOT OF FALLEN

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I

The genus *Corizus* of authors is in a mess. Signoret's famed Monograph started it. It was not improved by Hambleton's paper. And Uhler's activities but added to the confusion.

The trouble all springs from the constant description of species of *Corizus* by color *only*—all structural characters being thrown into the generic descriptions, or else utterly neglected. So it is that the widespread *C. crasicornis* Linné rejoices in at least *nineteen* synonymic and varietal names! The equally widespread *C. hyalinus* Fabricius is somewhat more modest—it has been redescribed only 12 times! Other species, being less universal and not so often seen, have been more fortunate—the relatively unknown American species have a short, if any, synonymy.

By 1870, a number of subgenera had been established, principally by Stål; some authors—Schilling, Spinola, Fieber—had made full genera in the group, later either sunk in the synonymy or reduced in rank to subgenera. These groups were based on structures. But species continued to be described and differentiated largely by color. Where structures were employed after 1870, they were not critical; the subgenera continued to be neglected; and species were still by color. An example is Uhler's *Corizus viridicatus*, which the author himself reduced to a variety of *C. hyalinus* Fabricius, on a basis of color! Had he paid any heed to structure, had he considered the already established subgenera, he would at once have seen that *viridicatus* fell in the subgenus *Stictopleurus* Stål 1870, and *hyalinus* in the subgenus *Liorhyssus* Stål 1870, both structurally set up on the same page in Enumeratio (I: 223)!

It is obvious that the majority of authors had before them recognizable and separable entities—in all probability, subconsciously at least, they recognized them by facies and frequently by structure. But the color obsession had laid its dead hand on them and they extended themselves in pages of

the subtlest changes in hue and tint, applicable perhaps to an individual or to a series of individuals identically colored and marked. Whoever subsequently ran across some specimen not four-square with Prof. Dr. Fulanus' color-characterization, blithely described a new species—if modest, a new variety. All of this but added to the babel (or babble) of names.

In 1908 Hambleton published his monograph of the North American species of *Corizus*. Here he boldly departed from the hallowed tradition and essayed a structural classification. He, however, neglected the already established subgenera and lumped the species all together in the one genus. Furthermore, he used a set of characters which, while incontestably valid, are frequently obscured and too often exceedingly subtle. He did not, for example, employ the valid and very obvious character of the transverse anterior ruga or carina of the pronotum; nor the equally valid and visible antennal and rostral characters; nor many more others which might be enumerated.

Now, if there is one thing that is obvious in *Corizus* as here styled, it is its consistent variability in depth or in lightness of color, both within the group and within the species, for an example of the latter, the one species *C. hyalinus*, so frequently redescribed.

This is not, and is not meant to be a definitive discussion of the group. It is simply meant to point out its chaotic condition and to bring out as forcibly as may be, the dire need of a monographic revision of the group, entailing the structural study of all available primary material in this country and abroad. Without this, we shall continue to grope in the dark.

As a beginning, I point out that there are in the Americas *at least* four subgenera. These, with their species as recognized, are definitely characterized thus, following Stål (Enumeratio 1: 223-224):

KEY TO THE AMERICAN SUBGENERA OF CORIZUS AUCTT.

1. Metapleura not divided into an anterior and a posterior area by a well-defined transverse suture, entirely coarsely punctate; posterior margin truncate or subtruncate and straight or subsinuate, posterior upper angle rounded.....Subgenus **Stictopleurus** Stål 1870

   Contained species:
   C. crassicornis Linné
   C. viridicatus Uhler

   Metapleura divided by a transverse suture into an anterior and a posterior area, the anterior area coarsely punctured, the posterior finely or obsoletely; posterior margin oblique and sinuate, posterior upper angle produced and rounded or acute.....2

2. Margin of the pronotum before the transverse anterior callus, ruga or carina unpunctured, or obsoletely? so; terminal abdominal segment short in both sexes, truncate in female, rounded in male, Subgenus **Liorhyssus** Stål 1870
Contained species:
C. hyalinus Fabricius

Margin of pronotum anterior to the transverse callus when present, or if absent, to the transverse suture, coarsely punctured; terminal abdominal segment in both sexes long, in female frequently pointed or acute, in male rounded.....3

3. Pronotum *without* an anterior transverse ruga or carina; head somewhat long, apex of tylus *not* or *very slightly* deflexed; apex of rostrum reaching to or slightly passing *posterior* coxae.....Subgenus **Niesthrea** Spinola 1840
Contained species:
C. sidae Fabricius

Pronotum *with* an anterior transverse ruga or carina; head short, part before the antennae shorter than wide, apex of tylus more or less deflexed; rostrum reaching to or beyond intermediate coxae, Subgenus **Arhyssus** Stål 1870
Contained species:
C. validus Uhler
C. lateralis Say
C. bohemanii Signoret
C. scutatus Stål
C. punctatus Signoret
C. indentatus Hambleton
C. tuberculatus Hambleton
C. parvicornis Signoret
C. hirtus Torre-Bueno

II

What is the true name of the genus? It has been pointed out by Reuter, Kirkaldy and Horváth, that *hyoscyami* Linné 1758 is the type of the genus *Corizus* Fallén 1814. Since this appears to be a valid genus with a number of good species, as monographed by Horváth, *Corizus* of authors must take another name. This appears to be *Rhopalus* Schilling 1829, type *capitatus* Wolff, according to Westwood, as cited by Van Duzee in his Catalogue. *Corizus capitatus* Wolff, which is *capitatus* Fabricius, according to Lethierry and Severin is the previously described *subrufus* Gmelin 1788. It should be pointed out, however, that Reuter in his Revisio, cites *tigrinus* Schilling as the type of the genus. To make this clear: *Rhopalus* Schilling 1829, type: *R. subrufus* Gmelin 1788 (=*capitatus* Fabricius 1794, Wolff et plurimis auctorum); or, type: *tigrinus* Schilling 1829. This genus contains a number of subgenera, set forth by Lethierry and Sévérin—*Stictopleurus* Stål 1870, *Peliochrous* Stål 1873, *Liorhyssus* Stål 1870, *Aeschyntelus* Stål 1872, *Niesthrea* Spinola 1840, *Arhyssus* Stål 1870, and *Rhopalus* Schilling 1829. Of these, the recognized American subgenera have been set forth on a preceding page. Of the other subgenera, the species pertaining to each are much in the air.

A monograph of the genus *Rhopalus* (=*Corizus* auctt., nec Fallén) and its allies is imperative if we are to have any clear concept of their limits and of their species.

III

A corollary to what precedes is the seemingly very vague idea of a species which appears to reign among hemipterists (and equally so among students of the other orders).

The fundamental, objective, taxonomic unit is the species. This is obvious. All groupings of species have a subjective element. But the species must be a fact, not a matter of opinion.

Now, what is a species? Is it a recognizable structural unit? Is it a conglomeration of color changes, far too frequently of the minutest kind? Or is it a subjective something that has no real existence outside of the individual mind?

To me, if a species be nothing but variable color, if it be nothing but a figment of the imagination, then the whole theory of the origin of species is as unsubstantial and as unreal as a fairy tale. A species *must* be a concrete objective something—or it is a tenuous unsubstantial nothing. Hence, a species *must* be a structurally definable unit with definite limits—it *must* be that, or it is nothing.

How frequently have color-species been shown to be nothing but seasonal or environmental or climatic forms? What guarantee have we that other—in fact, *all*—color species are nothing but variable forms of one and the same structural unit, namely, the true basic species?

I am well aware I am posing a deep fundamental question, but until we answer it definitely and positively, we will not know where we are going, nor why, nor how.

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***Gmelin, J. F.** 1788. Caroli a Linné Systema Naturae, Tomus I, vol. IV: 2041–2224. Describes *subrufus* under *Coreus*.

Hambleton, J. C. 1908. The Genus Corizus with a Review of the North and Middle American Species. Ann. Ent. Soc. Am. I: 133–152, pls. 8–11. The first attempt to place the genus *Corizus* on a structural basis.

Horvath, G. 1917. Species generis *Corizus* Fall. (*Therapha* Am Serv.) Ann. Mus. Nat. Hung. XV: 166–174. Points out that *Therapha* (A. & S.) *hyoscyami* L. is the type of *Corizus* Fallén; and describes a number of Old World species, with key.

Kirkaldy, G. W. 1903. The Nomenclature of the Genera of the Rhynchota; Heteroptera and Auchenorrhynchous Homoptera—The Entomologist XXXVI: 213—Points out that *C. hyoscyami* L. is the type of *Corizus* Fallén 1814.

Lethierry, L., and **G. Sévérin.** 1894. Catalogue général des Hémiptères, vol. II. Lists in alphabetical order all the Corizini described to that point.

Reuter, O. M. 1888. Revisio Synonymica. Points out that *C. hyoscyami* L. is the type of *Corizus* Fallén 1814; and that *Rhopalus tigrinus* Schill is the type of *Rhopalus* Schill.

***Schilling, P. S.** 1829. Hemiptera Heteroptera Silesiae systematice disposita. Beitr. Ent. schlesische Fauna I: 34–93, pl. 6. Establishes *Rhopalus*.

Signoret, V. 1859. Monographie du Genre Corizus—Ann. Soc. Ent. Fr. (3) VII: 75–105—Describes (and redescribes) many new species (and redescribes the others) on a basis of color, with perhaps an incidental structure in descriptions.

Spinola, M. 1837 (Note date). Essai sur les Genres d'insèctes appartenant a l'Ordre des Hémiptères Linn. ou Rhyngotes Fabr. et a la section des Hétéroptères, Dufour. Sets up the genus *Niesthrea* with *Coreus sidae* Fabr. as the example, i. e., type.

Stal, C. 1870. Enumeratio Hemipterorum I—Svensk. Vet.-Ak. Handl., no. 1: pp. 1–232. Enumerates the Coreidae (pp. 125–228), with keys to the subgenera of Corizida (Corizidae), old and new therein established.

Uhler, P. R. 1872. Notices of the Hemiptera of the western Territories of the United States, chiefly from the Surveys of Dr. F. V. Hayden. Report of the United States Geological survey of Montana. Describes *Corizus viridicatus* and mentions others.

1876. List of the Hemiptera west of the Mississippi River including those collected during the Hayden explorations of 1873. Sinks *viridicatus* as a synonym of *C. hyalinus* Fabr.

***Wolff, J. F.** 1800–1811. Icones Cimicorum descriptionibus illustratae.

STATISTICAL METHODS APPLIED TO EXPERIMENTS IN AGRICULTURE AND BIOLOGY, 3rd ed., by G. W. SNEDECOR. xiii 422 pp., 1940. The IOWA STATE COLLEGE PRESS, Ames, Iowa. Price $3.75, postpaid.

Since the appearance of the first edition in 1937, this book has enjoyed increasing popularity among biological and agricultural workers. The general usefulness of the work lies in the simple presentation of the basic logic of statistical theory and in the numerous examples of the application of statistical techniques to the types of data usually encountered in experimental work. Its popularity among teachers and research workers speaks for its clear style and thorough treatment of subject matter. The first and second editions have been reviewed in previous numbers of the ANNALS but the following points are worthy of notice.

The third edition has appeared under the imprint of The Iowa State College Press, whereas former editions were published by The Collegiate Press, Inc. This amounts essentially to a change in name, but it brings to this book, and future books, the approval of an editorial board composed of members of the staff of Iowa State College.

Parts of the new edition have been revised or rewritten and some new material has been added to Chapters 6 and 10. To Chapter 16 has been added a section illustrating transformations of data for tests of significance by use of the square root, the angle and the logarithm. A complete table of angle transformations is included.

A new chapter (Chapter 17) on the design and analysis of samplings has been added. This enlarges the scope of the book and should prove of particular interest to workers engaged directly or indirectly with population studies. It includes such topics as sampling from homogenous populations, size of sample, sampling from small populations, effect of errors in weights, the structure of sampling investigations and the effectiveness of stratification.—G. R. Ferguson.

A LUMINOUS FLY LARVA WITH SPIDER TRAITS

(Diptera, Mycetophilidae)[1]

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Points of bluish light glowing at night on the damp earth about a spring in western North Carolina led to the discovery of luminous, lochetic larvae living in webs after the manner of spiders. The worm-like larvae remained concealed in crevices during the day but at night they crawled out on the webs and exposed their glowing bodies. The spring was under some trees on the hillside back of a house that served as a field laboratory for work on the cabbage maggot at Glenville, Jackson County, N. C. Since I had no entomological literature at the field laboratory, I could find no clue to the identity of the larvae. Therefore, I attempted to rear some of them to maturity. When I confined the larvae in vials or Petri dishes on beds of moist peat, they built webs and lived normally while they were kept in a cool environment. Unfortunately, the field work was discontinued before any of the larvae matured. Two lots of larvae removed to Raleigh in June and July died from exposure to heat and no adults were reared during the first year. A year later I took larvae to Raleigh in an iced container and upon arrival kept them in a cool basement. From this lot I obtained several adults which were identified by Dr. Elizabeth Fisher as an undescribed species of *Platyura*. This determination was received in time to be included as a footnote in my brief account (1) of the habits of this species and some other web-spinning Mycetophilid larvae from eastern North Carolina. Later the luminous species was described by Fisher (2) as *Platyura fultoni*. Further observations have resulted in much additional information on the life history and larval behavior of this interesting species.

HABITAT AND DISTRIBUTION

The larvae are most easily collected after dark when they are revealed by their own light. They can also be found in the

[1]Contribution from the Department of Zoology and Entomology, North Carolina State College, published with the approval of the Director of the North Carolina Experiment Station as Paper No. 119 of the Journal Series.

daytime by carefully searching for the characteristic webs. They have been found only about springs or streams on a sloping substratum that is permanently moist but not subject to flooding. The webs are built on moss, rotten wood, in cracks between rocks or on bare soil, either sandy, stony or of a black peaty composition. The sites have all been shaded and many have been in the deep gloom under Rhododendron thickets. Only a few localities can be recorded but this is because no widespread search has been made for the species. Glenville, N. C., the type locality, is the only place from which adults have been reared. The larvae were found at several sites within a radius of several miles, including one at the foot of High Falls on the Tuckaseigee River. Larvae were also found at Highlands, N. C., and on both sides of the N. C.–S. C. state line along the highway south of Cashiers, N. C. Fisher (2) also records two male adults collected by A. L. Melander at Lewis Falls, Shenandoah National Park, Va. The altitude range in North Carolina is from about 2800 feet at High Falls to 3800 feet at Highlands.[2]

THE WEB AND ITS USE

The web always issues from a small cavity which may be a worm hole, a crevice between stones or under a stone, or merely a hiding place in the depths of a bed of moss. In the cavity the larva rests on a strand of web suspended by numerous branches radiating to the walls. The branch strands are beset with droplets of a clear liquid which is probably nothing but water, for when dried on a clean slide it leaves no deposit. At the surface the main strand usually forks and extends in two or more directions, suspended over hollow places by means of side strands. The whole exposed portion of the web thus consists of a flat spray of strands largely in one plane, covering an area as much as five centimeters across (Plate I, F). Most of the side strands are enlarged near their distal ends to form whitish spindles 2 or 3 mm. long (Plate I, G). The proximal end of the spindle tapers to a point but the distal end is abruptly rounded and is connected with the substratum by a thin strand less than a millimeter long. The spindles are composed of a

[2]On May 15, 1941 larvae were collected by the author near Danbury, Stokes Co. N. C. in the northwestern part of the state, at an elevation probably not over 1200 feet. They were numerous in a shallow cave by a waterfall where they had been observed but not identified several years ago by E. H. Hall, botanist at N. C. C. W. Greensboro, N. C.

very viscous material which adheres to anything touching it. The remainder of the web is not adhesive. The central strand, on which the larva rests, is ribbon-shaped but much narrower than the larva itself (Plate I, G).

The larva is held to the web by a coating of liquid which completely surrounds the body. It can glide forward or backward by peristaltic body movements and can reverse its direction by doubling back. It remains entirely on the central strands and merely reaches about with the anterior half of the body to build or repair the web or to capture prey. The posterior segment of the body is provided with a pair of pseudopods (Plate I, D) which serve to anchor the larva to the web. The larva is very sensitive to slight movements of the web. When an insect is caught in one of the adhesive spindles, either in daylight or darkness, the larva will dart out until it reaches that branch and follow it out to capture the victim. If the prey is too large to be pulled back at once into the den, the larva will attach additional strands of web to the prey and will crawl across its legs coating them with slime so that they stick together.

The web is not adapted to catching prey more than a few millimeters in length. Large insects would simply tear the web and escape. The only insect remains actually found in the webs were an ant and a first instar roach. Other insects such as aphids, small flies and Collembola when placed in the web were taken indiscriminately. Soft bodied insects were usually entirely devoured, leaving no carcass in the web. The most abundant insects found in the natural habitat were Collembola and it seems probable that they form a considerable part of the normal diet. The caged larvae were fed mostly on worker termites because they were easily obtained. Small spiders dropped into the web were also subdued and devoured quite as readily as insects. This is of interest because of the reversal of the proverbial roles of the spider and the fly. In this case a juvenile fly captures a spider, and does so by the same method used by the spider in capturing the adult fly.

Normally the repair and extension of the web is a nocturnal activity but if a larva is removed from its web and placed in a suitable environment it will construct a new web at once. It crawls into the nearest depression and reaches from side to side with the anterior portion of the body. When the head touches something a thin thread is drawn out from the mouth.

The larva then thrusts the head toward the opposite side and as it does so the first thread slips back from the head but remains attached to the body. The larva thus moves slowly forward fastening threads alternately, to right and left and soon has itself suspended in mid air by the tension of the attached strands. As it passes farther along, the proximal ends of the threads, which appeared to be attached to the body, are found to be connected to a ribbon-like central strand. Since the side strands apparently issue from the mouth, it seems possible that their substance originates in the well developed salivary glands. The origin of the central strand is more mysterious as it is formed without any apparent effort on the part of the larva. Although the larva in building a web often backs up after laying a few side strands, it appears to do so on a central strand already formed. After watching this and other web-spinning Mycetophlidid larvae constructing webs I am inclined to believe that the central strand originates as a slimy secretion from the ventral side of the body. It is probably the same slime that is deposited on the legs of a struggling victim in the web.

No adhesive spindles appear in the newly constructed web but are added later, usually after dark, on entirely new side strands. The construction of the spindles was observed only a few times. The larva reached out until it made contact with the ground, then paused and worked the head rapidly in and out of the anterior body segment. At the same time peristaltic waves passed along the body toward the head. Then the larva touched the ground again and pulled out a very short thread of the usual size, this was followed by a thick thread apparently issuing from the mouth as the larva pulled back slowly, working the head in and out as before. The thick thread tapered off and was followed by a thin thread.

It was evident that the adhesive material was incorporated in the strand while it was being drawn out and that it was not applied as a coating to a strand previously formed. Apparently some effort was required to disgorge the viscous substance. Since the thin thread is not sticky, it appears that two substances can be produced at will from the mouth of the larva. Dissection shows only two organs connected with the mouth, the salivary glands and the alimentary canal itself. The salivary glands are a pair of simple tubes slightly enlarged into storage vesicles near the anterior ends. They are filled with a viscous material that could be the substance of either the ordinary web or the

sticky spindles but hardly both. The actions of the larva before drawing the adhesive portion of the strand suggest the possibility that this material may be a mixture of salivary substance with liquid from the outside of the body or from the alimentary tract. Another possibility is that the thin strand is also a product of integumental slime as I believe the central ribbon-like strand to be and that the adhesive bodies alone come from the salivary glands.

LUMINESCENCE

The light given off by the larvae is not nearly as bright as the flash of a firefly. In brilliance it approximates the glow given off by some of the Lampyrid larvae. Had I not noticed the distinct bluish color of the lights I might have assumed them to be Lampyrid larvae. The main light is given off by the five anterior body segments which occupy about a fifth of the body. There is also a small tail-light which includes the small posterior segment (Plate I, A).

The first larvae to be studied were captured at night. They remained luminous during handling and after confinement but when I examined them in a dark closet the following day they proved to be non-luminous. Further observations showed that the larvae were luminous only part of the time but their behavior in this respect could not be explained. I assumed that some factor of confinement might be responsible for the loss of luminosity. This theory was exploded the following summer when larvae collected during the day were taken at once to the dark closet and found to be non-luminous.

In order to study the luminescence under conditions simulating the natural habitat of the larvae, a sloping bed of peat was built in a pound coffee can of the broad type. Two pieces of 18 mm. shell vial about an inch long and open at both ends were imbedded horizontally in the surface of the peat so as to leave only a small space on the upper side unfilled and uncovered. A small wooden block placed over this part kept the inside of the tube dark but permitted inspection of the interior at any time. Larvae placed in these tubes built webs over hollow places provided in the surface of the peat which was kept constantly wet.

For the period from May 18 to 24 I kept this preparation during the day near a window in the field laboratory, where it was not exposed to direct sunlight. Several times each day I

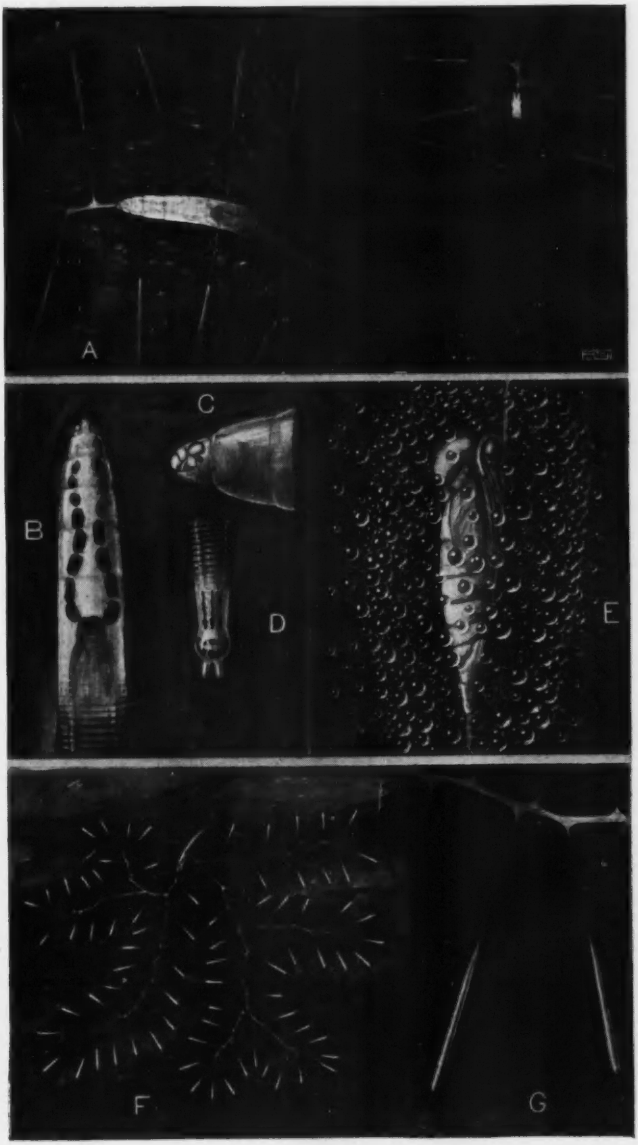
took it to the dark closet for examination but the larvae were never found to be luminous at such times. In the evening I would take it to my bed room and darken the room by pulling the blind at about 8 P. M. while it was still not entirely dark outside. During the next half hour the larvae would become luminous. The inception of illumination, when observed, varied from 8:10 to 8:30. A faint glow appeared at first and increased to full intensity after several seconds.

The appearance of luminescence was observed a number of times to be followed shortly by the beginning of nocturnal activity by the larvae, which would come out of their holes and make additions to the web. Having finished this they would remain most of the night with the luminous fore part of the body exposed, resting on one of the main strands below the entrance of the cavity. Handling the container or blowing on the webs caused the larvae to retreat into their dens but they did not go dark. Light from a flash light for short duration also did not affect their luminescence, but when the room was illuminated with a kerosene lamp for a quarter hour or more the larvae would be found non-luminous when the room was again darkened. Occasionally late at night either one of the larvae would be found dark or glowing very faintly. They were usually found glowing when the birds first started singing in the morning but never after it was so light that the room had to be darkened to detect luminosity.

Since it appeared from these observations that continued exposure to light, even a weak light, caused the larvae to go dark, I wanted to know whether exposure to prolonged darkness could induce luminescence in the daytime. On the morning of May 24 I took the can containing the two larvae to the field laboratory and placed it in the dark closet, which was completely dark except for some indirect light filtering through cracks which became visible only after the eye was accommodated to darkness. For the next few days I looked in the closet at intervals of an hour or two during the daylight hours and never found the larvae luminous.

EXPLANATION OF PLATE I

Platyura fultoni Fisher. A. Larva as it appears when luminous; headlight at left; tail-light, upper right. B. Cephalic photogenic region by daylight. C. Lateral view of head and first segment. D. Caudal photogenic region by daylight. E. Pupa in cocoon. F. Larva in cavity with web exposed below. G. Detail of portion of main strand with two side strands bearing adhesive spindles.


A
B
C
D
E
F
G

On the evening of May 28 after the larvae had been in constant darkness for four days, I prepared a light-tight cover for the can and removed it to my bedroom. At 8 P. M. I made the room entirely dark by pulling the shade, and then removed the cover from the can. Neither worm was glowing. With a watch and flash light at hand I watched the spot where the can was located. At exactly 8:30 one light came on and at 8:37 the other one appeared. By that time it was nearly completely dark out of doors. In the morning after the can had been exposed to light for about an hour, I replaced the light-tight cover and left it until darkness came on the following evening. When the cover was removed at 8:10 P. M. one larva was already glowing and the other one became luminous at 8:38.

These observations reveal that the larvae have a daily rhythm of illumination and activity which is continued under conditions of uniform darkness. Temperature remained a variable factor in the experiment, although less variable than in the natural habitat. The factor of humidity was nearly constant, being close to saturation in the cavity in the wet peat. A similar periodicity of activity has been found in a number of other nocturnal insects including the cockroach, *Blatta orientalis* L., two species of Coleoptera and three species of Orthoptera, as reported in articles by Gunn (3), Mellanby (4), Park and Keller (5), Park and Sejba (6), and Lutz (7).

THE PHOTOGENIC ORGANS

Both the cephalic and caudal light producing parts of the body have a milky white appearance by daylight in contrast with the brown pigmented non-luminous portions of the body. Internal organs are visible through the unpigmented integument in both luminous parts and both contain small black bodies which are not present in other parts of the body. In the cephalic region these are arranged in two sinuous rows and have the appearance of strings of jet beads, with 5 to 8 in each row, and not always with an equal number on the two sides (Plate I, B). The caudal segment has a small group of rounded or irregular shaped black bodies in the posterior part and anterior to these a group of three longitudinal thin bodies (Plate I, D). As near as could be determined by gross dissection, the black bodies are closed sacs well supplied with tracheal branches but having no other connections. Those in the cephalic part are strung along the main tracheal trunks which

give off branches to each body. No counterparts of these structures have been found in the larvae of several non-luminous species in the same genus or related genera, although in most other respects their anatomies are similar.

When the larvae are dissected under water the black bodies soon start to disintegrate and a sepia colored material diffuses into the water. When I examined such a preparation in the dark under a dissecting microscope, I found that the black bodies and the water surrounding them were distinctly luminous. When the remains of the dissected larva were shaken up in a vial with a little water, all of the water exhibited a faint glow when examined in the dark.

Starting with another fresh living larva, in a drop of water, I examined it in the dark and found it to be non-luminous. Under the dissecting microscope I then punctured one of the black spots in the caudal segment with the point of a fine insect pin. When again examined in the dark a small glowing spot could be seen distinctly at the point of injury. I then removed the posterior half of the larva and cut open the skin of the remaining part as far as the cephalic photogenic region without producing any luminescence. The skin was then carefully opened to the head without injuring the black bodies and still no light was produced. Then with a pair of needles I broke open some of the black bodies. In dim light a diffused glow could be seen spreading through the surrounding water. In complete darkness the whole mass of water was streaked with a beautiful bluish light. By shifting from darkness to light and back again I was able to determine that the light was strongest where the sepia colored material from the black bodies was most concentrated.

From these observations it appears that the black bodies are the photogenic organs. When a larva is examined in the dark under a dissecting microscope during the luminous period the light does not appear to come directly from the black bodies. Instead, the whole fore part of the body is illuminated (Plate I, A). The black bodies are not distinctly visible either as bright or dark objects but the region where they are located does not appear to shine quite as brightly as the lateral edges of the segments when viewed from above.

The photogenic organ of this species is an entirely different structure from that found in the New Zealand glowworm, *Arachnocampa luminosa* (Skuse), which is also a lochetic, webspinning Mycetophilid. Its photogenic organ has been studied in some detail by Wheeler and Williams (8). It is

located in the caudal segment and includes the enlarged tips of the four Malpighian tubules lying parallel over a reflecting layer. The light is described as bluish-green.

LIFE HISTORY

The earliest seasonal observation on the species was made on April 22, 1939, when two larvae were collected at night. At the altitude of Glenville, about 3500 feet, it was still early spring. The larvae, which were little more than half grown, probably had passed the winter at a stage of growth not much different from that found. At that time the larvae could not be found by looking for the webs in daylight but a search in the same places in mid-May revealed them readily. Undoubtedly they were present earlier but had not yet constructed webs.

When full grown the larva attains a length of about 15 millimeters, by about one millimeter in diameter. The body is cylindrical with a pair of very faint dorso-lateral folds or ridges. The head capsule is typical of the family as shown in Plate I, C, and Plate II, figs. 1 and 2. The first five body segments are white with transparent integument (Plate I, B) and the rear end tapers to a small rounded tip which is also white (Plate I, D). These two parts contain the black photogenic bodies as previously described. Just back of the cephalic photogenic region there is a large median black body visible through the integument. This is the truncated anterior end of the fat body surrounding the oesophagus and crop. The remainder of the fat body has a pale purplish color, and is concealed under the brown pigmented integument extending from this point to the caudal segment. The pigmented segments are elongated, with very indistinct boundaries, and the pigment is disposed in narrow transverse bands giving the appearance of annulations, so that the insect resembles a small annelid worm.

When about to pupate the larva stops feeding and becomes somewhat shorter and stouter. It spins within the cavity a delicate cocoon-like structure whose walls consist of a network of fine threads loaded with droplets of clear liquid (Plate I, E). The outermost meshes are supported by numerous strands radiating to the walls of the cavity. The denser portion is oval in shape and about one centimeter long by half as wide. On the main strand which passes through the hollow interior of the cocoon the larva transforms to a pupa of the exarate or free type. The cast larval skin is worked back to one end of the cocoon while the pupa remains in the middle.

When the fly (Plate II, 3 to 8) emerges it also remains in the center of the cocoon and works the pupal skin toward the rear where it clings to the main strand with the cast larval skin. The adult rests in the cocoon for a day or two before forcing its way through the meshes to escape. No effort was made to keep the flies alive and most of them were promptly killed for specimens when found. One specimen died in the vial after depositing 82 unfertilized eggs. The eggs were ovoid, .25 by .30 millimeters with glossy, black, thin, flexible chorion. Previously a single egg had been found protruding from the abdomen of a newly emerged fly that had just been killed and pinned. This egg was in every way similar to those described except that it was white. I do not know which represented the normal condition or whether the eggs are all white when first deposited and turn black later. The black eggs did not appear to be discolored for only the chorion was black.

All observations on the pupa and adult stages were confined to specimens kept in vials at Raleigh. The pupa stage was of short duration. The earliest cocoon was built on June 3, 1939, the pupa was probably formed on June 4 and the adult emerged on June 9. A second fly emerged June 10 from a larva that spun a cocoon on June 4. Other adults from this lot of specimens continued to emerge up to June 19. These adults may have been somewhat in advance of the main brood, since they had been kept indoors and had been fed fairly regularly. At any rate larvae were found plentiful at Glenville on a later trip on June 17. In 1940 some larvae were collected south of Cashiers on June 21 and adults from these specimens emerged at Raleigh as late as July 13. In 1938 larvae were found at Highlands on July 11 but no adults were reared. It would be reasonable to expect the flies to be present about the larval habitats during most of June and July.

The remainder of the life history is unknown. Evidently the eggs are deposited within a short time after the emergence of the adult but no very young larvae were ever found. The size of the web would be limited by the size of the larva and the first web made by a newly hatched larva must be a very fragile

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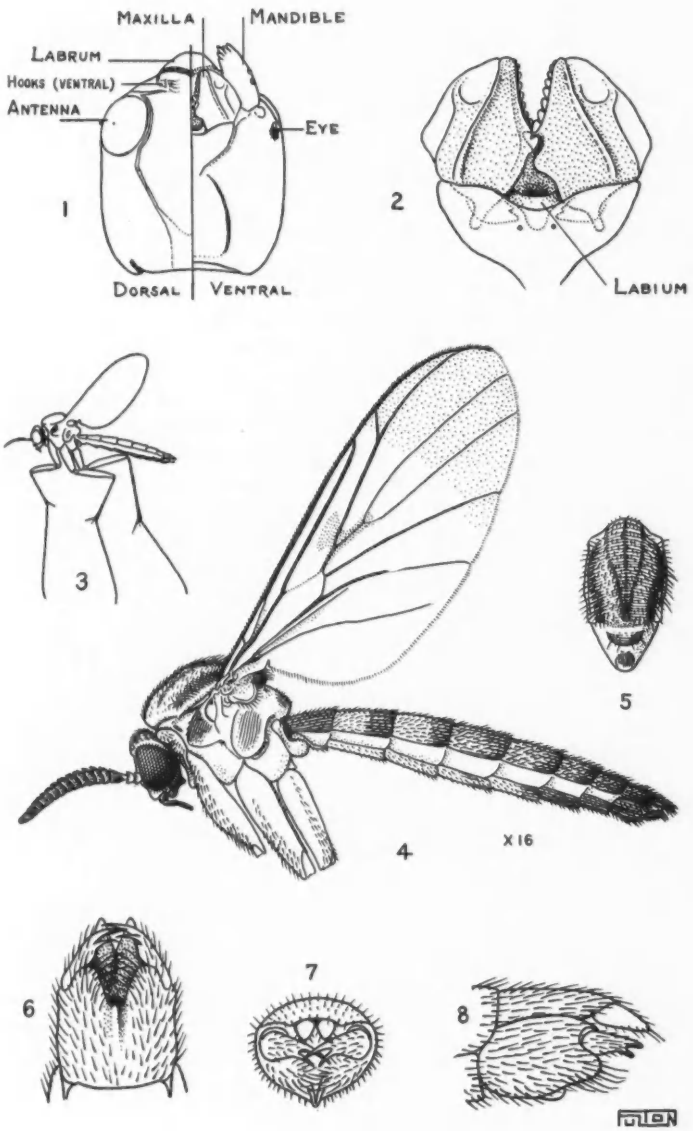
EXPLANATION OF PLATE II

Platyura fultoni Fisher. 1. Larval head capsule. 2. Larval maxillae attached to maxillary plate, ventral view, with portion of labium visible. 3 to 8. Male paratype. 5. Dorsal view of thorax. 6 to 8. Ventral, caudal and lateral views of terminalia.


MAXILLA
MANDIBLE
LABRUM
HOOKS (VENTRAL)
ANTENNA
EYE
1
DORSAL
VENTRAL
2
LABIUM
3
4
X16
5
6
7
8
FULTON

affair capable of ensnaring only the smallest of insects or mites. Judging by the rate of development of the older larvae it seems improbable that there would be more than one generation a year.

PARASITE

A hymenopterous internal parasite emerged from one of the larvae and was found in a brownish silk cocoon. The adult appeared on June 27, 1939, and was identified by R. A. Cushman as an undescribed species of Dallatorrea.

SUMMARY

The luminous larvae of *Platyura fultoni* Fisher have been found in wet, shaded places about springs and streams in the southern Appalachians. They build branching webs with thickened adhesive bodies near the ends of the branches and feed on small insects caught in the webs. They remain hidden in cavities during the day but at night they crawl out on the webs and expose their luminous bodies. Luminosity, associated with increased activity, is confined to the hours of darkness. The larvae have a daily rhythm of illumination which is continued for at least six days in complete darkness. The photogenic organs are small black bodies located in the cephalic and caudal ends of the body.

There is probably not more than one generation a year. The larvae probably live over winter partly grown. The pupa stage, in a frail cocoon, is of short duration. The flies occur in June and July. One larva was parasitized by an undescribed species of *Dallatorrea*.

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NOTES ON ERORA LAETA (EDWARDS) AND ERORA QUADERNA (HEWITSON)

(Lepidoptera, Lycaenidae)

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Erora laeta (Edwards) has long been thought to occur in two widely separated areas; the first area consisting of parts of the northeastern United States and southeastern Canada and the second, of parts of the southwestern states. An investigation of the southwestern records has shown that they are based upon inaccurate determinations and that the two regions are inhabitated by two distinct species, *Erora laeta* in the northeast and *Erora quaderna* (Hewitson), a species originally described from Mexico, in the southwest. This will doubtless surprise many workers as the name *Erora laeta* (Edwards) is represented in most of the North American collections and museums solely by southwestern specimens. It seems less surprising, however, to find that this southwestern species is really a species found in nearby Mexico than a New England and eastern Canadian species not known to occur in any locality nearer than fifteen hundred miles distance. *Erora quaderna* is here recorded for the first time as occurring within the boundaries of the United States. Descriptions of the two species follow.

Erora quaderna (Hewitson)

(Plate I, figs. 4, 5, 6, 8; Plate II, figs. 5, 6, 7, 8; Plate III, figs. 11, 12, 13)

Thecla quaderna Hewitson, 1868, Descr. Lycaenidae, p. 35. Mexico.

Thecla quaderna Hewitson, 1867–1877, Ill. Diurn. Lepid., p. 209, pl. 83, figs. 703, 704. Mexico.

Thecla laeta Edwards, 1883a, Papilio, 3: 8. Mt. Graham, Arizona, thirty specimens.

Thecla quaderna Godman & Salvin, 1887, Bio. Centrali-Americana, 2: 60. Las Vegas, Mexico, and Quiche Mountains, Guatemala.

Thecla laeta Coolidge, 1910, Can. Ent., 42: 374. Huachuca Mts. and Chiricahua Mts., Arizona.

Erora laeta Clark, 1932, Butt. Dist. Columbia, p. 250, pl. 25, figs. 5, 6. Prescott, Arizona.

Erora laeta sanfordi dos Passos, 1940, Am. Mus. Nov., no. 1052, p. 2. White Mts., Arizona, five males and three females (holotype and allotype and paratypes); Santa Catalina Mts., Arizona, three males, one female; Chiricahua Mts., Arizona, one male; Chiracqua, Arizona, one male; Southern Arizona, three males, six females; Arizona, one male; Mud Springs, Santa Catalina Mts., Arizona, one male. All paratypes, except holotype and allotype mentioned above.

Male.—Wings above mummy-brown[1] with bronze-like cast, particularly in base of hind wing and a faint, narrow, broken, marginal line of deep, soft, blue-violet between veins M_3 and 2nd A in this wing. A small patch of salmon-orange scales at anal angle of this same wing just below vein 2nd A.

Mummy-brown fringe of scales around outer margins of fore and hind wing on upper side. Hind wing with fringe of long dirty-white, scales, overlapped at bases by mummy-brown scales. This fringe replaced by long, dirty-white hairs along the abdominal margin of hind wing. Numerous, long, mummy-brown hairs in base of fore and hind wing and in and below discal cell of hind wing.

Hind wing below corydalis-green or mytho-green. Sometimes replaced by smoke-grey as is shown in Godman & Salvin's figures of *attalion*, here considered to be a dimorphic form of the species. Fore wing drab except along costal margin and across apex and downward along outer margin almost to anal angle where drab is replaced by corydalis- or mytho-green. Hind wing with irregular submesial row of eight very small salmon-orange spots. These spots outlined by a few black and white scales along their outer sides. Between anal and outer angles of hind wing is found a submarginal row of salmon-orange dots, seven in number, which are very small, often composed of as few as four scales. Usually one to four black scales and a few white scales associated with these dots.

On under surface an irregular, obscure, dark brown line crosses forewing from near costal margin to vein Cu_2. A few white scales are scattered along the outer side of this line. This line, corresponding to the submesial line or row of spots usually found in lycaenids, in this species is located considerably nearer to the outer margin than is usual. Costal margin of forewing from base to apex salmon-orange. A few yellow scales along inner side of this orange margin in base of wing.

Fringe along outer margin of forewing on under surface composed of long drab scales with shorter overlapping scales of dark brown. Along the outer margin of hind wing a dirty-white fringe with shorter, overlapping scales of drab and dark brown, with a few orange scales at ends of veins in lower half of wing. Along abdominal margin, a fringe of grey hairs. These grey hairs found also in abundance in base of hind wing and in lower half of this same wing.

Female.—Wings above dark mummy-brown with narrow, broken, marginal line of deep, soft blue-violet between vein M_3 and 2nd A in hind wing. A heavy suffusion of this same color in base of forewing below the discal cell and in hind wing in discal cell and interspaces M_3, Cu_1 and Cu_2 almost to marginal blue-violet line just described, separated from it by a band of brown, almost two millimeters wide or frequently by small brown spots, one each in these three interspaces.

Outer margin of forewing fringed with long scales of yellow and shorter, overlapping scales of salmon-orange. At inner angle this fringe replaced by fringe of scales and hairs of brown. Fringe of hind wing with long scales of white and shorter overlapping scales of brown with a few orange scales scattered along the outer margin in upper half

[1]Color nomenclature used in this paper is from Ridgway, 1912.

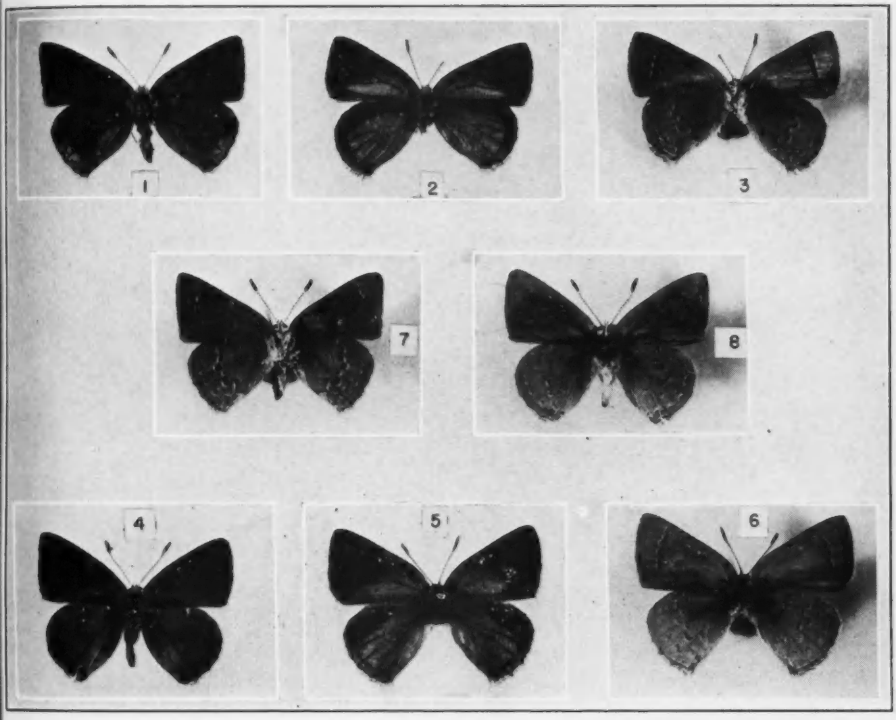


Fig. 1. *Erora laeta* (Edwards). Male, upper side. Bear Mt., near Bridgewater Corners, Vermont. May 31, 1937. 2. *Erora laeta* (Edwards). Female, upper side. Bear Mt., near Bridgewater Corners, Vermont. May 30, 1937. 3. Under side of fig. 2. 4. *Erora quaderna* (Hewitson). Male, upper side. Huachuca Mts., Arizona. March 1st through 7th. Barnes Collection. 5. *Erora quaderna* (Hewitson). Female, upper side. Arizona. Barnes Collection. 6. Under side of fig. 5. 7. Under side of fig. 1. 8. Under side of fig. 4.

of wing. In lower half of this margin, brown fringe scales almost replaced by orange scales. A few scales of brown extend out beyond the white ones in this same region. A fringe of dirty brownish-white and brown hairs along abdominal margin. Numerous long greyish-white hairs in base of forewing and in and below discal cell of hind wing.

Wings below corydalis-green or mytho-green. Sometimes area below discal cell and throughout lower half of forewing a very light drab with greenish reflections. When this is true, the specimens have the appearance of being slightly worn, and the drab color is probably due to the fading out of green. All orange markings more pronounced than in male. The eight salmon-orange spots of the submesial row of hind wing narrow and elongate, not or scarcely connected, having the appearance of a wavy line. This line is salmon-orange on the forewing, not brown as is true of the male. These spots outlined by a few black scales and beyond this by white ones on their outer sides. This is especially evident in forewing, whereas in the male, the submesial line is closer to the outer margin than is true of this line in most lycaenids. Submarginal salmon-orange spots of hind wing much larger than in male, each spot containing at least eighteen orange scales and usually more. Entire costal margin of forewing salmon-orange in color.

Fringe along outer margin to inner angle composed of long scales of yellow and shorter, overlapping scales of orange. Fringe of hind wing composed of dirty brownish-white scales with shorter overlapping scales of salmon-orange. Toward anal angle, longer scales of brown. On abdominal margin of hind wing fringe replaced by grey hairs. These grey hairs found also in base and along lower half of this wing.

Male genitalia.—Seven specimens of *quaderna* were dissected and these dissections were compared with dissections of two males of *laeta*. The genitalia of *quaderna* were found to be constant for the characters given below and since the two specimens of *laeta* differed widely from normal variation in *quaderna*, *laeta* was assumed to be constant. In *quaderna* the oedeagus is relatively longer with a much longer opening at the back for the ductus seminalis and with a foreward pointing distal process along one side. The cornutus of the oedeagus is also relatively narrower and longer than in *laeta*. The clasper of *quaderna* is relatively narrower with a shorter and less erect distal process. The socii are relatively shorter and broader than in *laeta* and the saccus is narrower and more triangular in outline.

Female genitalia.—Ten specimens of *quaderna* females were dissected and compared with dissections of three female specimens of *laeta*. Both species were found to show constant characters. The most striking difference in the egg laying apparatus was found in the ovipositor struts or the anterior apophyses. These were found to be only gradually and evenly bent at about one-third their distance from their connections with the ovipositor lobes in *quaderna*. The heavily sclerotized plate in the anterior part of the bursa copulatrix, just below the opening of ductus seminalis is much longer and narrower in *quaderna* than in *laeta*. The signae of bursa copulatrix are armed with small teeth along their free margins in *quaderna*. The dorsal margin of the basal end of ductus bursae is more evenly rounded in *quaderna* than in *laeta*.

New synonymy.—A study of the pair of paratypes of *Erora laeta sanfordi* dos Passos in the United States National Museum shows that *sanfordi* is a synonym of *E. quaderna* (Hewitson).

Note.—The above description is based upon a series of eleven specimens from Mt. Graham, Arizona, material from New Mexico, Oak Creek Canyon and the Santa Rita Mountains in Arizona, from the Francis Huntington Snow Entomological Museum and thirty-four specimens (16 males and 18 females) from the Barnes Collection of the United States National Museum, taken at Paradise, Redington, Palmerlee, Prescott, Senator, Santa Catalina Mountains and Huachuca Mountains, all in Arizona, and one female from the Barnes Collection taken in Utah by Bruce.

Distribution.—The known distribution can be summarized as follows: *Mexico*—Las Vegas, "Mexico;" *Guatemala*—Quiche Mountains; *Arizona*—Mt. Graham, Huachuca Mts., Chiricahua Mts., Prescott, Oak Creek Canyon, Santa Rita Mts., Paradise, Redington, Palmerlee, Senator, Santa Catalina Mts.; *New Mexico; Utah.*

Variation.—According to Mr. J. F. Gates Clarke of the United States National Museum, Dr. Benjamin left a note with the series of thirty-four Arizona specimens, tentatively determining the species as *Thecla attalion* Godman & Salvin (1887, 2:60; 3: pl. 35, figs. 19, 20). Godman and Salvin's figures of the male agree entirely with male specimens of *quaderna* from Arizona, except that the greenish ground color on under side of wings is replaced by brownish-buff in the base and lower half of both fore and hind wing in their illustration of *attalion*, whereas, in nineteen of the twenty Arizona males before the writer, this region of the hind wing is entirely greenish. In the other male both wings are entirely brownish-buff underneath. Whether this brownish color is due to a fading out of the green or not cannot be ascertained. *Attalion* is here treated as a dimorphic form of male *quaderna*, the name being used for the form lacking green color on under surfaces. It should be borne in mind that such specimens may not occur in nature except in a worn state. Dr. Draudt (1924, p. 783) seems to believe that *attalion* is the male of *quaderna*.

Erora laeta (Edwards)

(Plate I, figs. 1, 2, 3, 7; Plate II, figs. 1, 2, 3, 4; Plate III, figs. 9, 10)

Thecla laeta Edwards, 1862, Pr. Acad. Nat. Sci. Phil., p. 56. London, Ontario, Canada. Two male specimens.
Thecla clothilde Edwards, 1863, Pr. Ent. Soc. Phil., 2: 15. City of Quebec, Canada. One female specimen.
Thecla clothilde Scudder, 1868, Pr. Bost. Soc. Nat. Hist., 11: 377. Paris, Maine.
Thecla laeta Edwards, 1869, Butt. No. Amer., 1: Thecla I, 2 pp., 4 figs. in color. Coalburgh, West Virginia. *Clothilde* listed as a synonym of *laeta*.
Erora laeta Scudder, 1872, Syst. Rev. Butt., p. 32. Genus *Erora* erected for *Thecla laeta* Edwards.
Thecla laeta Strecker, 1878, Syn. Cat. Macrolepid., p. 90. "Southward to Virginia."
Thecla laeta Mead, 1882, Papilio, 2: 18. Coalburgh, West Virginia. One specimen.
Thecla laeta Edwards, 1883, Papilio, 3: 8. Catskills, New York.
Thecla laeta Edwards, 1883b, Papilio, 3: 123. Coalburgh, West Virginia. One specimen.
Thecla laeta Fernald, 1884, Butt. Maine, p. 83. Orono, Maine.
Thecla laeta Murray-Aaron, 1884, Papilio, 4: 22. Atlantic City, New Jersey. One specimen.
Erora laeta Scudder, 1889, Butt. East. U. S., 2: 819–822; 3: pl. 14, figs. 6, 9. St. Joachim, Quebec; Norway, Maine; Williamstown, Massachusetts.
Thecla laeta Wind, 1891, Can. Ent., 23: 96. St. Hilaire, Quebec. One male.
Thecla laeta Fyles, 1897, Ann. Rept. Ent. Soc. Ont. 1896, p. 12. Sherbrooke, Quebec. One specimen.
Thecla laeta Young, 1904, Ann. Rept. Ent. Soc. Ont. 1903: 91. Meech Lake, Quebec. Two specimens.
Thecla laeta Russell, 1907, Ann. Rept. Ent. Soc. Ont. 1906: 92. Digby, Nova Scotia. One specimen.
Thecla laeta Young, 1908, Ann. Rept. Ent. Soc. Ont. 1907: 119. Meech Lake, Quebec. Two specimens.
Erora laeta Mousley, 1923, Can. Ent., 55: 29. 16-Island Lake, Argenteuil Co., Quebec, two females; St. Hilaire, Quebec; Hatley, Quebec; Mt. Orford, Quebec.
Erora laeta Forbes, 1928, List of Insects of New York, p. 680. Keene Valley, New York; Cortland, New York; Ithaca, New York.
Erora laeta Dos Passos & Grey, 1934, Can. Ent., 66: 191. Paris, Maine; Lincoln, Maine; Mt. Desert (Bar Harbor), Maine.

Male.—Wings above fuscous or fuscous-black with distinct bluish tinge in fore wing, particularly in basal half and with broad, marginal, rectangular band of olympic-blue (sometimes described as metallic-blue) on hind wing between veins M_3 and 2nd A. This band merges with marginal blue line of hind wing found below vein M_3 and encloses small points of black, one each in these three interspaces. In a specimen from the Great Smoky Mountains, marginal blue band reduced to a blue lunule, pupilled with small black spot in interspace Cu_1. Also a slight blue coloring in interspace Cu_1 in this region. Otherwise this specimen is quite similar to one from Vermont on the upper side.

Outer margins of fore and hind wing fringed with long white scales with an overlapping row of fuscous scales. At inner angle of both fore and hind wing, white scales become dirty-white. Numerous long fuscous-black hairs in base of forewing and in and below discal cell of hind wing.

Hind wing below light terre verte or perhaps Niagara-green, as in Edwards' illustration (1869, 1: Thecla I). Apex and costal margin of forewing same color. Over rest of forewing green heavily suffused with fuscous. Submarginal row of orange spots more reddish in color than

in *quaderna* and composed of rather small spots. These spots, however, more distinct than in *quaderna*. Spots of submesial row also reddish in color and much larger than in the male of *quaderna*, being squarish and connected. Lower two of spots of this row in forewing tinged with fuscous. In the specimen from the Great Smoky Mountains, all red markings are smaller on the wings below than in the specimen from Vermont. In Great Smoky Mountains specimen, also, lower four of spots of submesial row in forewing tinged with fuscous. Spots of submesial row in both wings of *laeta* outlined very faintly with black and strongly with white. This white purer than in *quaderna* giving reddish spots a more distinctive appearance than in that species. Sometimes a narrow, distinct bar of red crosses end of discal cell of hind wing. This bar is either absent or very faint in *quaderna*. Costal margin of forewing orange or reddish in color, more distinct in basal two-thirds than in outer third.

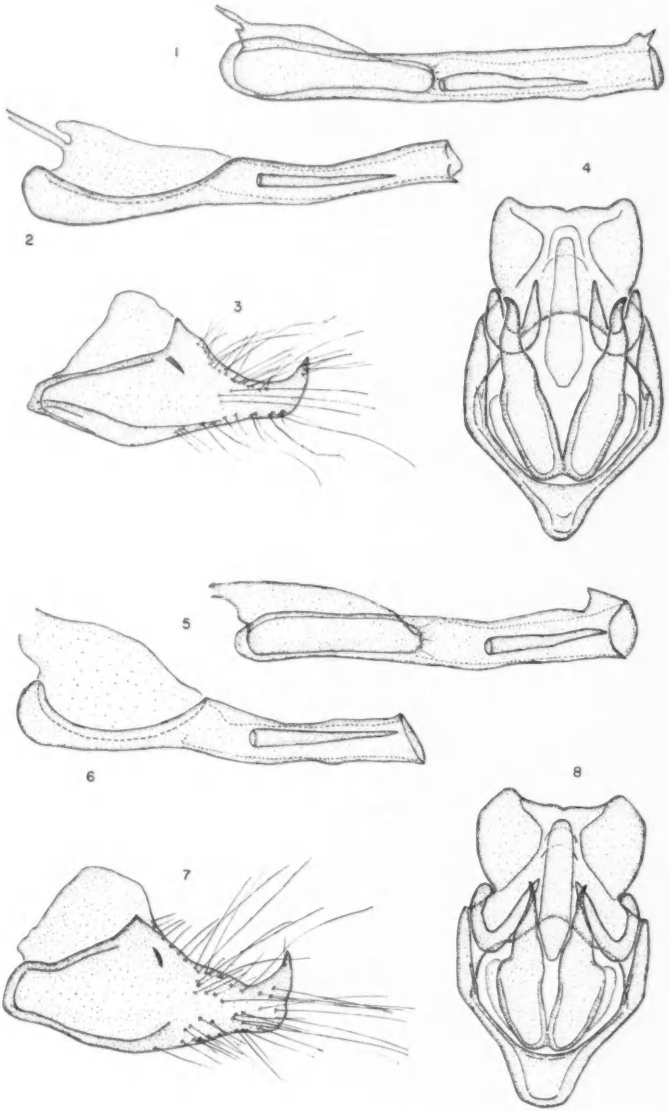
Fringe along outer margin of fore and hind wing on under side composed of long scales of dirty-white and shorter overlapping scales that are only slightly darker in color. A few orange scales in hind wing at ends of veins Cu_1 and Cu_2. A greyish-white fringe of hairs along abdominal margin with hairs of same color in base and lower half of hind wing.

Female.—Wings above fuscous, fuscous-black or sometimes mummy-brown, with narrow continuous marginal line of mazarine-blue between vein M_3 and 2nd A in hind wing. Base of fore wing in interspace Sc, discal cell and basal third of interspace M_3, basal half of interspace Cu_1 and nearly all of interspaces Cu_2 and 2nd A, except outer fifth of these last two interspaces, olympic-blue in specimen from Mt. Killington, Vermont, and in Edwards' illustration (1869, 1: Thecla I). However, in a Nova Scotia specimen, this color is pale, soft, blue-violet, and in a specimen from Mt. Washington a plumbago-blue. In hind wing, this same blue color extends through discal cell and interspaces M_3, Cu_1 and Cu_2 outward to marginal, mazarine-blue line, described above, leaving a small round spot of fuscous or mummy-brown in each of interspaces M_3, Cu_1 and Cu_2.

Outer margin of forewing above fringed with long scales of white and with overlapping salmon-orange scales. These orange scales are much less numerous than in *quaderna*. At inner angle, fringe composed of dirty white and brown scales. Hind wing with long white fringe scales and with shorter overlapping scales of brown, a very few longer brown scales extending beyond the white ones and many shorter overlapping orange scales. Along abdominal margin fringe of scales replaced by fringe of white hairs. Numerous long white hairs in base of forewing and in and below discal cell of hind wing.

EXPLANATION OF PLATE II

Fig. 1. Dorsal aspect of oedeagus of *Erora laeta*. 2. Lateral aspect of oedeagus of *Erora laeta*. 3. Lateral aspect of clasper or harpe of *Erora laeta*. 4. Ventral aspect of male genitalia of *Erora laeta* with oedeagus removed. 5. Dorsal aspect of oedeagus of *Erora quaderna*. 6. Lateral aspect of oedeagus of *Erora quaderna*. 7. Lateral aspect of clasper or harpe of *Erora quaderna*. 8. Ventral aspect of male genitalia of *Erora quaderna* with oedeagus removed.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Wings below light terre verte in the specimen from Mt. Killington, Vermont, and in Edwards' illustration (1869), 1: Thecla I). However, Edwards described this color as a "greenish-grey loosing the greenish tinge on inner margin of primaries." In the Nova Scotia specimen (mentioned above) this color is pale, olive-buff with a slight tinge of green and in the specimen from Mt. Washington, New Hampshire (also mentioned above), this color is a smoke-grey, with very faint greenish tinge. Whether this variation in ground color underneath, represents racial or individual variation cannot be determined at present because of the scarcity of material. It is also possible that the green color of typical *laeta* is faded from the Nova Scotia and New Hampshire specimens (before the writer) due to the age of the material (collected in 1906 and 1921 respectively). Orange markings more pronounced than in the male. Eight submesial spots of hind wing on this surface almost connected, forming a wavy line, outlined on outer side by a few black scales and beyond this by white. This black and white lining is especially evident in forewing. These orange submesial spots are not at all suffused with brown as is true of the male. Submarginal salmon-orange spots of hind wing slightly more distinct than in the male. In Edwards' figure of the female (l. c.), these spots are extremely large and squarish, forming a continuous connected row. This is true also in the specimen from Mt. Killington, Vermont. In the specimen from Nova Scotia and the one from New Hampshire, they are not nearly so large. The basal two-thirds of the costal margin of forewing yellow-orange in color, the distal one-third black.

Fringe along outer margin of forewing on under side composed of long white scales and short scales of orange. At inner angle, orange and white scales replaced by dirty brownish white ones. Fringe of outer margin of hind wing white with shorter scales of orange and dirty brownish-white. In lower half of this wing, orange scales very evident in fringe, and in addition to long white scales, there are a number of longer brown scales at the anal angle. Along abdominal margin of hind wing, there is a fringe of white hairs which are also quite numerous in base and along lower half of wing. The description of fringes given above is that of the Vermont and Nova Scotia specimens before the writer, with which the illustration (l. c.) in Edwards' work entirely agree. In the New Hampshire specimen, the fringe is much darker, white scales entirely lacking and replaced by dirty brownish white or grey scales.

Male genitalia.—Two male specimens of *laeta* were dissected and as mentioned before, were found to differ widely from *quaderna*. The clasper of *laeta* is relatively shorter and broader, with a more erect and longer distal process. The oedeagus is shorter, with a shorter opening for the ductus seminalis and with a recurved, hook-like, distal process along one side. The cornutus is relatively shorter in *laeta*. The socii are longer and narrower in *laeta* than they are in *quaderna* and the saccus is broader and nearly squarish in outline.

Female genitalia.—The three female specimens (from Nova Scotia, New Hampshire and Vermont) were dissected and found to differ strikingly from *quaderna*. The ovipositor struts or anterior apophyses are very sharply bent in *laeta* at about one-third their distance from their

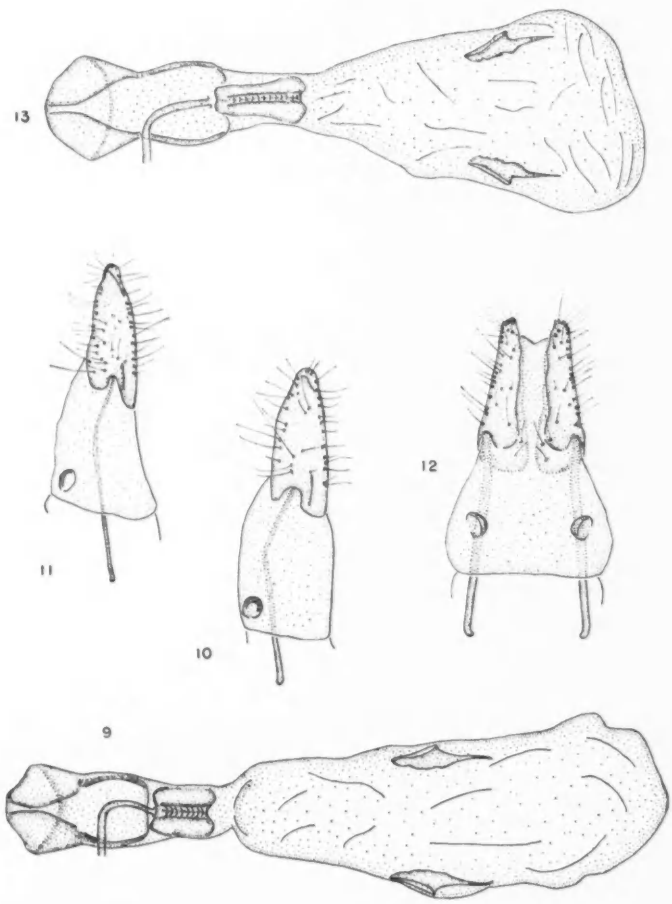

Fig. 9. Dorsal aspect of ductus bursae and of bursa copulatrix of *Erora laeta*. 10. Lateral aspect of ovipositor of *Erora laeta*. 11. Lateral aspect of ovipositor of *Erora quaderna*. 12. Dorsal aspect of ovipositors of *Erora quaderna*. 13. Dorsal aspect of ductus bursae and of bursa copulatrix of *Erora quaderna*.

bases. The heavily sclerotized plate in the anterior part of the bursa copulatrix, just below the opening of the ductus seminalis is much shorter and broader in *laeta* than it is in *quaderna*. The signae of the bursa copulatrix are smoother, not apt to be armed with as many small teeth along their free margins in *laeta* as they are in *quaderna*. The dorsal margin of the basal end of ductus bursae is angled along the sides and flattened across the top in *laeta*.

Note.—The above description is based upon a pair of specimens of *laeta* (furnished by A. C. Frederick) from Mt. Killington, Vermont, two female specimens from the Barnes Collection from Digby, Nova Scotia and Mt. Washington, New Hampshire, and a male specimen from the Great Smoky Mountains National Park, Tennessee, and the descriptions and illustrations given by Wm. H. Edwards (see bibliography) as well as notes supplied by Dr. A. E. Brower.

Distribution.—The writer has been able to add a few more localities to the published records of *laeta* through correspondence with several collectors. Dr. Murray-Aaron states that he used to take *laeta* rather frequently both at Atlantic City and Cape May, New Jersey. Mr. L. P. Grey, of Lincoln, Maine, writes that he has a female specimen from Huntington, West Virginia. Mr. A. C. Frederick, of Albany, New York, says that he took three females at Mt. Equinox near Manchester, Vermont, in 1935 and in 1937 found two males and nine females along the slopes of Mt. Killington, some fifty miles to the northeast. This is perhaps the greatest number of specimens of *laeta* that has ever been taken at any one locality. Mr. Frederick further states that during the 1938 season he went to the same locality on five different days over a period of two weeks and did not see a single specimen. Again during the 1939 season on one trip he saw a specimen but did not capture it. On April 15, 1938, a male specimen of *laeta* was taken on the upper part of Little River in the Greak Smoky Mountains National Park, Tennessee, by Mr. Arthur Stupka, Park Naturalist. There is a specimen of *laeta* in the Barnes Collection of the United States National Museum, taken by Mr. L. W. Swett, at the base of Mt. Washington, New Hampshire.

The total known distribution can be summarized[2] as follows: *Ontario*—London; *Quebec*—City of Quebec, St. Joachim, St.

[2]H. G. Dyar (1902, p. 40) gives the locality of *laeta* as Montana and Colorado and in doing so ignores all of the other records of *laeta*. This together with the fact that the above reference is the only one available in which these two states are given as localities for *laeta*, leads the present writer to believe that they were cited in error.

Hilaire, Sherbrooke, Meech Lake, 16-Island Lake, Hatley, Mt. Orford; *Nova Scotia*—Digby; *Maine*—Paris, Bar Harbor, Lincoln, Orono, Norway; *Vermont*—Mt. Equinox, Mt. Killington; *New Hampshire*—Mt. Washington; *New York*—Catskill Mts., Keene Valley, Cortland, Ithaca; *New Jersey*—Atlantic City, Cape May; *Massachusetts*—Williamstown; *West Virginia*—Coalburgh, White Sulphur, Huntington; *Virginia; Tennessee*—Great Smoky Mts. National Park.

COMPARATIVE NOTES

The males of these two species are very easily distinguished from each other by the presence of the broad marginal rectangular blue band on the upper side of the hind wing in *laeta*. *Quaderna* lacks this band but has the narrow, broken, marginal line of blue in this region. The black coloring of the upper side of *laeta* is darker, not the brownish black of *quaderna* and is very slightly suffused with blue.

The females of these two species differ in the amount of blue coloring of the upper surfaces. In the forewings of *quaderna*, this coloring is greatly reduced when compared with *laeta*, not extending beyond the basal one-half of interspace Cu_2 and 2nd A. Whereas, in *laeta*, this coloring is found throughout the discal cell and interspace Sc as well as in the base of interspace Cu_1 and M_3. In the hind wing, also, this coloring is reduced in *quaderna* female, usually not extending to the marginal broken blue line as in *laeta*, but leaving a band of fuscous at least two millimeters wide between it and the marginal blue line or enclosing rather large brownish black spots in this region.

Underneath, the ground color is very different, as described. That of *laeta* is terre verte or Niagara-green in both sexes and that of *quaderna*, corydalis or mytho-green in both sexes. As mentioned above, however, this color may be nearly replaced by a drab color in the female of *quaderna* or smoke-grey in the male of this species (f. *attalion*) while in *laeta* it may be replaced in the female sex, by smoke-grey or a pale, olive-buff. On the under side of the fore wing of *quaderna* male, the color is chiefly drab, except along costal margin, apex of wing and outer margin which is the same color as the hind wing. In *laeta* male, the fore wing on this surface is entirely terre verte or Niagara green, but the base of forewing may be slightly clouded with fuscous.

Other differences between the two species are described above, chiefly the coloration of the fringe scales and the form of the male and female genitalia, however, the characters mentioned in this section (comparative notes) are the ones that are most easily observed.

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A NEW SPECIES OF HAPLIDUS

(Coleoptera: Cerambycidae)

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Haplidus laticeps n. sp.

Male.—Narrow, elongate, shining, brunneus, head darker, pubescence short, recumbent, interspersed with longer scattered flying hairs.

Head including eyes wider than prothorax; front vertical, with median sulcus, rugose; eyes large, coarsely granulate, emarginate; antennae slender, extending two joints beyond apices of elytra, scape stout, second joint somewhat longer than wide, third joint longer than scape, fourth joint shorter than third, fifth joint longer than fourth, sixth and seventh joints length of fifth, eighth, ninth and tenth joints equal, each slightly shorter than seventh, eleventh joint longest; palpi subequal, slender, last joint cylindrical.

Pronotum as long as wide, narrower than elytra, slightly wider at base than at apex; sides evenly rounded; disk flattened; surface finely densely punctured between irregular median and lateral smooth areas. Scutellum semicircular, finely punctured.

Elytra elongate; sides parallel at base, constricted at middle, expanded back of middle, apices broadly rounded; surface finely, densely punctured, punctures same size as those of pronotum.

Abdomen beneath with fine punctures, shining.

Length 9.9 mm.; width 2.2 mm.

Female.—Antennae not reaching to apex of the elytra.

Holotype male labeled Sonora, Tex., April, 1931. Allotype from the same locality, April 5, 1932, S. E. Jones, Tex. Experiment Station light trap.

I am indebted to Mr. H. J. Reinhard for the privilege of describing the species and retaining the holotype.

This species would probably stand next to *H. testaceus* Lec. in the key erected by Linsley.[1] It can be separated by the head being wider than the narrow, very finely punctured pronotum.

[1]E. G. Linsley, Pan Pacific Ent., 8, No. 3, p. 113, 1932.

TAXONOMIC INVESTIGATIONS OF SOME TERMITOPHILOUS STAPHYLINIDAE OF THE SUBFAMILIES ALEOCHARINAE AND TRICHOPSENIINAE (NEW SUBFAMILY)

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During his investigations of the termite faunae of the neotropics and the United States, Dr. Alfred E. Emerson has collected from the nests of these social insects a most remarkable series of termitophilous arthropods of a number of families. Most of this material has already been taxonomically considered; the Coleoptera by Mann (1923, 1926) and Seevers (1937, 1938, 1939), Diptera and Hymenoptera by Brues (1923, 1932), Hemiptera by Morrison (1923), Diplopoda by Chamberlin (1923), and the Collembola and Thysanura by Folsom (1923). These collections were made at the Tropical Research Station of the New York Zoological Society at Kartabo, Bartica District, British Guiana, in Trinidad, on Barro Colorado Island in the Canal Zone, and in various localities of the United States.

The present paper is concerned with a series of minute staphylinid beetles from these collections. Upon initial examination it appeared that these small beetles are closely related since they exhibit more or less the same general appearance, i. e., having the pronotum expanded to more or less cover the deflexed head, and the abdomen tapering strongly to an acute apex. A detailed examination of slide mounts soon revealed, however, that three distinct groups of staphylinids are represented.

Two of the new species from British Guiana are clearly related to the North American termitophilous genera, *Trichopsenius* Horn and *Xenistusa* Leconte. These new species are distinctive in a number of respects and are made the types of two new genera, *Pulicipsenius* and *Rhinotermopsenius*. During the detailed examination of these four genera it became more and more evident that they are very distinct from the genera of the subfamily Tachyporinae with which *Trichopsenius* and *Xenistusa* have long been classed. This association with

the tachyporines seems to have been based on very superficial characters since some of the morphological characteristics, especially the relationship of the metathoracic legs to the metasternum and the structure of the male genitalia, are very unusual and remarkable. As a matter of fact, it is difficult to find basic characters to link this group with the tachyporines. The writer is of the opinion that these genera occupy a rather isolated position in the Staphylinidae and that this can best be expressed by elevating the tribe Trichopseniini of the Tachyporinae to subfamily rank. In the account which follows, the new subfamily Trichopseniinae is characterized, two new British Guiana genera of this subfamily are described, a new Florida species of *Xenistusa* is described, and other genera which belong to this subfamily (*Trichopsenius*, *Termitopsenius* Wasm. of Argentina, and *Hamitopsenius* Wasm. of Sumatra) are briefly discussed.

The second group of species in this series of neotropical termitophiles appears to have affinities with the Aleocharinae but at the same time presents some rather unusual features. The six new species of this group are assigned to five new genera which are believed by the writer to deserve tribal rank. Certain features of the head structure are quite distinctive. The new tribe Termitohospini is characterized herein, and five new British Guiana genera, *Termitohospes*, *Termitocolonus*, *Termitosodalis*, *Termitosocius* and *Paratermitosocius* are described. *Callopsenius* Wasm., a termitophilous genus from Paraguay, formerly assigned to the subfamily Cephaloplectinae, is believed to belong here.

The three new species of the third group are members of the aleocharine tribe Termitonannini. This tribe has been represented by a single genus, *Termitonannus* Wasm., with three species from southern Brazil, Paraguay, and Argentina. Two new Panamanian species are added to this genus, and a British Guiana species is made the type of a new genus, *Termitocomes*.

The neotropical species were collected by Dr. A. E. Emerson and Mrs. Lysbeth Hamilton Benkert, and the new species of *Xenistusa* from Florida was collected by Miss Olive Falls. Holotypes are in the collection of the writer, and the paratypes in the collections of Dr. A. E. Emerson and the writer. The identifications of the host termites were made by Dr. Emerson.

Trichopseniinae new subfamily

Tribe **Tachyporini,** Group II. *Trichopsenii* Leconte and Horn, 1883, p. 100.
Subfamily **Tachyporinae,** Tribe *Trichopsenini* Eichelbaum 1909, p. 196.

Since their discovery and description, the two North American termitophilous genera *Trichopsenius* and *Xenistusa* have been regarded as tachyporines. It was early recognized that they are different enough from the other tachyporines to be placed in a separate group, but this has not always been followed as they are included with the Hypocyptini in Leng's catalogue. Wasmann (1902) placed these genera in the Cephaloplectinae for a time but later (1916) regarded them as tachyporines.

The most important subfamily characteristics are as follows:

Habitus variable, ranging from a limuloid form with a somewhat conical non-physogastric abdomen (*Pulicipsenius*, fig. 14) to a distinctly physogastric form with swollen, somewhat membranous abdomen (*Xenistusa*, fig. 19).

Head deflexed, more or less concealed by pronotum; or in the usual position (*Xenistusa*).

Vertex large; the postclypeus very short or absent, since the anterior tentorial pits are situated very close to the front margin of the head capsule (fig. 2).

Antennae inserted medial to the eyes; somewhat removed from the anterior tentorial pits. This departure from the typical staphylinid situation, in which the anterior arm of the tentorium is closely associated with the antennal fossa, is an unusual feature of the trichopsenine head.

Gula moderately heavily sclerotized (*Trichopsenius, Xenistusa*), the gular sutures terminating at the posterior tentorial pits so that the submentum is continuous with the postgenae laterally (fig. 10); or the gula membranous or absent (*Pulicipsenius, Rhinotermopsenius*) and the submentum distinct from the postgenae (fig. 9).

Glossae very short, slightly rounded; paraglossal lobes large.

Labial palpi 3-segmented, the third segment bearing a slender terminal spicule (except in *Xenistusa*); the second segment globose (fig. 11), distinctive in appearance.

Maxilla (fig. 9, 10) with cardo transversely elongated; galea and lacinia subequal in length; galea truncate apically and bearing a group of long hairs or bristles; lacinia slender, apex forming an incurved hook, medially spinose or setose before the apex.

Maxillary palpi 4-segmented, the fourth segment bearing a terminal spicule except in *Xenistusa*.

Antennae 11-segmented. The antennae of *Termitopsenius* and *Hamitopsenius* are said to be 10-segmented.

Pronotum and elytra quite variable in size, form and pilosity.

Prosternum short, transverse. Anterior coxae long, varying from a compressed to a very convex form; trochantin quite long and slender.

Mesosternum short, with a process extending for a short distance between the nearly contiguous, large, oval middle coxae.

Metasternum very large and very aberrant in structure; produced ventrally as a thin plate extending laterally from the median line. This plate which extends the length of the metasternum is capable of covering a part of the trochanter and femur of the metathoracic legs. Figure 15 illustrates the left half of the metasternum with the plate in position and the right half with the ventral plate removed to show the relationship of the hind leg to the metasternum.

The hind leg is noteworthy in the apparent dissociation of the trochanter and coxa, and the articulation of the former directly with the metasternum. As a rule in the Staphylinidae, the hind trochanters articulate with several condyles of the distal end of the coxae while the hind coxa articulates medially with the metasternum and laterally with the metepisternum. In this group, the coxae are short and appear to be fused with the metasternum medially while articulating with the metepisternum laterally. The hind trochanter, however, is a large, somewhat oval, compressed structure with a large spherical head which extends into an opening in the metasternum in front of the hind coxae to articulate with two condyles of a slender medial structure (fig. 15–18). The ventral aspect (fig. 15) shows one of these condyles and the dorsal view (fig. 16) shows the other, while the enlarged dorsal view (fig. 17) indicates both of these condyles in the absence of the trochanter. The origin of this medial piece which bears the condyles is difficult to determine. The writer is inclined to consider it a part of the metasternum although it may be a part of the coxae extending forward as there is no apparent suture between it and the coxae. The line of demarkation between the coxa and metasternum seem to be indicated, however, by a vertical apodeme indicated in figures 16 and 17.

In the dorsal view (fig. 16), the metasternal furca is shown as well as a large, free, endoskeletal structure which is probably the muscle disk which has separated from the furcal arm. This muscle disk, which varies considerably in size and shape in the genera examined, is the point of origin of a small muscle to the head of the trochanter. Two large muscles originating from the apodeme on the lateral border of the metasternum insert on the head of the trochanter; the larger of these is probably a depressor and the smaller one probably an elevator muscle of the leg. The exact points of insertion of these muscles on the trochanter head is, however, difficult to determine. The trochanter contains a large fan-shaped muscle (fig. 15) which is probably a depressor muscle of the femur.

Tarsi 5-segmented; the first segment of the middle and hind tarsi greatly elongated, so that these tarsi are longer than the tibiae.

Abdomen physogastric in some genera so that the tergites and sternites are separated by membranous areas. Paratergites absent.

Male abdomen and genitalia.—Eighth tergite large (fig. 21), concealing the smaller ninth tergite. Eighth sternite arcuate (fig. 22), concealing the small ninth sternite (fig. 23). Lateral plates of the ninth segment elongated, stout; protruding conspicuously from the apex of the abdomen (fig. 19, 20); with a dorsal transverse process extending medially

from the base, and articulating basally with a long, slender anteriorly directed apodeme. Aedeagus remarkably enlarged, occupying a large part of the abdomen posterior to the third segment (fig. 29). Median lobe composed of a large bulbous basal portion and a more slender distal part (fig. 24). The proximal part bears condyles for the articulation of the lateral lobes and is composed of two sclerotized sections separated by a membrane. The distal part contains the eversible inner sac and the flagellum into which the ejaculatory duct opens. Lateral lobes large, composed of a series of sclerotized areas (fig. 26); the distal sclerite may be greatly elongated as in *Trichopsenius* (fig. 29) in which case it protrudes from the apex of the abdomen even when the genitalia are not extruded.

Female abdomen.—Eighth tergite and sternite much as in the male; the tergite may be incised at the apex as in *Trichopsenius*. A small sclerite, the proctiger (regarded as the tenth tergite), is concealed by the eighth tergite; this sclerite articulates laterally with long, stout paraprocts (regarded as derivatives of the ninth tergite.) A small sternite on the ventral side, transverse in *Trichopsenius* (fig. 27) and elongated in *Pulicipsenius* (fig. 28), is difficult to homologize.

The species are all termitophilous; *Trichopsenius* and *Xenistusa* inquilinous with several species of *Reticulitermes*, *Pulicipsenius* and *Rhinotermopsenius* with *Rhinotermes*, *Termitopsenius* with *Neocapritermes*, and *Hamitopsenius* with *Amitermes*. Very little is known regarding the relationships of these beetles to their hosts. The physogastric nature of several of the species is suggestive of a symphilous relationship although there is no evidence that they elaborate exudates upon which the termites feed. The structure of the metathoracic legs and the extreme development of the musculature associated with them is apparently an adaptation for jumping although not all of the species are known to do this. Dr. Emerson kept the two Guiana species under observation and noted that they were capable of jumping for distances which are considerable in view of their small size. *Pulicipsenius acanthoscelis* was observed to jump more than an inch when disturbed, although sometimes it required several minutes of stimulation before this took place. This species was observed riding on the back of a worker termite on one occasion. *Rhinotermopsenius saltatorius*, a physogastric species, was observed to jump even farther, a jump of three inches being recorded on one occasion. The termites did not react noticeably to either of these species of beetles. The writer has observed *Trichopsenius* and *Xenistusa* in laboratory colonies and has never observed that either species jumps. *Trichopsenius* has the odd habit of running along under a worker termite for considerable periods of time.

Genus **Trichopsenius** Horn

(Figs. 3, 7, 11, 27, 29)

Horn: 1877, p. 88.

Head strongly deflexed; pronotum moderate in size, front margin partially covering the head. Sides of pronotum slightly deflexed; the anterior and lateral margins continuously arcuate; basal border arcuate, posterior angles rounded. Pronotum two-thirds as long as wide.

Dorsum of head illustrated by fig. 3. The antennal fossae are closer to the anterior tentorial pits than in the South American genera. Labrum distinctive. Antennae as shown in fig. 7. Mandibles simple. Gular region, labium and maxilla resembling those of *Xenistusa* (fig. 10). Terminal segments of labial and maxillary palpi bear slender spicules and the second segment of labial palpi (fig. 11) is slightly different.

Elytra as wide as pronotum and a little longer, the sides straight, and the apical border of each elytron slightly arcuate. Elytra very conspicuously adorned with rows of very long yellow setae.

Prosternum short, transverse. Proximal portion of the front coxa slender, articulating with a long slender trochantin; the distal three-fourths broad, having the ventral surface very strongly convex, and the upper surface deeply concave.

Metasternal structure and articulation of the hind leg as described in subfamily characterization. The ventral plate of the metasternum extending laterally far enough to be capable of covering most of the trochanter and proximal part of the femur in repose.

Abdomen feebly inflated (incipiently physogastric); the sides of the abdomen not converging posteriorly except to a slight degree in some individuals. Paratergites absent.

Sclerites of the terminal abdomen segments of the male as figured for *Xenistusa* (figs. 20–23). Eighth tergite of female different in having a moderately deep, rounded incision at apex. Terminal sclerites of female as described in subfamily account and illustrated in fig. 27.

Aedeagus of male remarkably large (fig. 29), occupying most of the abdomen posterior to the third segment. Distal sclerite of lateral lobe long and slender, protruding from abdomen.

A single species, *T. depressus* Leconte (*Hypocyptus depressus* Lec., 1863, p. 30), apparently has a wide distribution as it has been recorded from Florida, Georgia, Massachusetts, Indiana, Illinois, Tennessee, Louisiana, Texas, and California (?). It occurs with various species of *Reticulitermes*, having been recorded with *R. flavipes*, *R. hageni*, and *R. arenincola*.

Genus **Xenistusa** Leconte

Leconte: 1880, p. 167.

Leconte described three species of this genius, *X. cavernosa*, *X. fossata*, and *X. pressa*, from three individuals collected from a single colony of "*Termes flavipes*" in the trunk of a fallen tree at Columbus, Texas. Schwarz examined the types a few

years later and reported (Proc. Ent. Soc. Wash. 1, 1888) that he could not distinguish among them. The dried type specimens were undoubtedly distorted as these species are physogastric and the membranous areas shrink badly upon dessication. It is not very likely that three specimens of the same genus of termitophiles from the same colony of termites would represent three species, yet the differences described by Leconte are quite pronounced. The writer is inclined to follow Schwarz in regarding Leconte's material as representing only one species, although this is difficult to establish.

The Florida specimens in the collection of the writer seem to represent a new species for they differ materially from Leconte's descriptions. The description which follows is intended to augment and clarify the original generic description. Since the material is preserved in alcohol the proper relationships are maintained.

Xenistusa hexagonalis n. sp.

(Figs. 6, 10, 19–26)

Length, 1.9–2.1 mm.

Head and prothorax slender; mesothorax, metathorax and abdomen strongly inflated, ovoidal. Considerable white membrane is exposed on the sides of the thorax and abdomen and between the sclerites on the dorsum and venter of the abdomen. Sexes differing somewhat in color and size; male head and thorax light, reddish brown, the abdominal sclerites paler, those of segments 3–6 testaceous, others darker; female generally darker, head and thorax brown, abdominal sclerites light, reddish brown. The sexes agree in length, but the females are more robust and the head, pronotum and elytra are larger as measurements below indicate.

Head scarcely deflexed, only the base of the occiput is covered by the pronotum. Dorsum of head similar to that of *Trichopsenius* (fig. 3), the antennae inserted anterior and slightly medial to the eyes, the inner apical angle of the antennal fossa closer to the anterior tentorial pits than in any other genus of the group. Vertex broadly and shallowly concave, with 2 setae between the antennae and 2 on the anterior margin of the head. Postclypeus very short; labrum broadly and moderately emarginate, the emargination with membranous tissue, trisetose near outer apical angle. Mandibles simple. Eyes moderately large.

Scape of antenna (fig. 6) somewhat compressed; second segment short, moderately globose; segments 3–10 increasing in width, eleventh short and broadly transverse.

Gula (fig. 10) broad, trapezoidal, the base shallowly concave; gular sutures apparently terminating at the posterior tentorial pits so that the submentum is continuous with the postgenae laterally. Postgenae declivous lateral to the submentum and densely and finely pilose. Mentum moderate in size, base straight, sides strongly arcuate, apex con-

siderably narrower than base, the existence of a suture between the mentum and prementum doubtful. Prementum feebly sclerotized; palpigers moderately large; glossae between their apices small, bisetose; paraglossae very large lobes dorsal to the palpigers and palpi. Labial palpi 3-segmented, second segment globose, third segment without terminal spicule.

Galea and lacinia subequal in length; the apex of the lacinia in form of a strong, slightly incurved hook, and the medial border at its base with 4 rather strong setae. Apex of galea rounded and narrow, the medial border setigerous near apex. Maxillary palpi 4-segmented (fig. 10), fourth segment without terminal spicule.

Vestiture of the pronotum as follows: 6 setae at the center of the disc arranged to form a hexagon, 3 on each side of this group forming a large triangle, 6 on the anterior border, 4 on the lateral border and 4 on the basal border. Elytra rather densely setose, the moderately long, pale hairs arranged in 6–8 irregular, longitudinal rows of 8–10 hairs.

The following measurements of two females and two males indicate a size difference in the sexes: female head .47 mm. wide, male head .42 mm. wide; female pronotum .54 mm. wide and .35 mm. long, male pronotum .45 mm.–.50 mm. wide and .30 mm.–.32 mm. long. Pronotum moderate in size, approximately two-thirds as long as wide, not much broader than the head.

Apical border of the pronotum bisinuate, the medial arcuate portion slightly emarginate; pronotum covering a small part of the occiput so that there is no membranous area between head and pronotum as described by Leconte for the other species. Anterior angles of pronotum broadly rounded; pronotum widest a short distance behind the front margin, the sides converging rather strongly to form an even and continuous arc with the base.

Elytra slightly broader than pronotum and nearly twice as long, the following measurements indicating sex differences: female elytra .60 mm. wide and .65 mm. long, male elytra .52 mm. wide and .55 long. Sides of elytra nearly straight, the posterior border of each elytron evenly arcuate. Medially each elytron is bevelled for its entire length, the V-shaped groove thus formed between them is quite conspicuous. Elytral surface with a very narrow, slit-like groove on the anterior two-thirds near the lateral border. Epipleurae bent at right angles to the elytra a short distance from the sides; the sides of the elytra appearing carinate.

Prosternum very short medially and extremely thin laterally. Trochantin very thin and long; anterior coxa slender basally, clavate distally, surface somewhat convex, upper surface nearly flat or slightly concave.

Mesosternum short, with a very short process extending between the coxae to meet a long slender process extending forward from the metasternum to feebly separate the middle coxal cavities. Metasternum long, strongly convex, the sides almost vertical. The median area expanded laterally into a ventral plate which is very short anteriorly and incapable of covering any of the retracted femur but which posteriorly is expanded into a rounded lobe to cover the medial half of the

trochanter in repose. Hind coxa short and transverse; articulation of hind trochanter as described in subfamily diagnosis.

Femora and tibiae strongly compressed, moderately broad. Front tibia a little shorter than femur, with a terminal circle of 10 small spines and a short spinule on the outer border. Middle tibia shorter than femur, becoming broader distally, bearing 2 moderately strong terminal spines and several spinules and a spinule on outer border. Hind tibia as long as femur, much expanded apically, sparsely clothed with short, stout setae and with a terminal circle of spines, the outer pair and the medial pair longer.

Tarsi 5-segmented; the first 4 segments of the front tarsi subequal, fifth longer; basal segment of the middle tarsi nearly equal to the remaining 4 segments, the fifth as long as the 3 preceding segments together; the first segment of the hind tarsus longer than the rest of the segments together; second, third and fourth decreasing in length, fifth equal to third and fourth together. Tarsi rather densely setose beneath.

Sclerites of abdominal segments 3–7 separated due to inflation of the abdomen. Paratergites absent. Tergites 3–7 increasing slightly in length posteriorly; sides tapering, rounded. Sternites 3–7 not overlapping the tergites, rounded at sides.

Male.—Eighth tergite moderately large, the apex strongly arcuate (fig. 21); basal margin of the eighth sternite deeply emarginate, the apical border arcuate with a slight sinuation laterally (fig. 22). The ninth sternite small (fig. 23), concealed by the eighth. Ninth tergite (fig. 20) smaller than the eighth and concealed by it, articulating at the sides with the large lateral plates of the ninth segment. The lateral plates, which protrude from the apex of the abdomen, produced at base to form a slender medial arm which terminates freely in front of the ninth tergite. The lateral plates articulate basally with long slender apodemes which extend apically on the ventral side as far as the fourth abdominal segment. These dark, slender structures are easily visible through the thin sternites and membrane of the venter (fig. 19). Aedeagus composed of the bulbous median lobe and large lateral lobes. The median lobe (fig. 24) having the bulbous proximal part composed of several sclerites and two dorsal condyles for the articulation of the lateral lobes. Median lobe traversed by slender ejaculatory duct which terminates in the flagellum distally (fig. 25). Lateral lobes composed of several sclerites, the terminal one shorter and broader than in *Trichopsenius* and not protruding from abdomen.

Female.—Eighth sternite shorter than that of the male, moderately arcuate; the eighth tergite similar to male yet somewhat shorter. The eighth tergite not incised at apex. Lateral plates (paraprocts) very broad basally, abruptly narrowed to a slender tapering distal half, in this respect differing from *Trichopsenius*.

Type locality: Gainesville, Florida.

The male holotype, female allotype and three paratypes were collected by Miss Olive Falls from a colony of *Reticulitermes hageni* Banks (4, III, 1938).

While there is no question that this species belongs to the genus *Xenistusa*, it is difficult to harmonize the structure of the pronotum with Leconte's generic and specific descriptions of it. The generic description is as follows: "pronotum rounded, broadly concave bilobed, lobes converging behind and covering the scutellum, rounded in front, triangular space between them membranous;" for *X. cavernosa*, "prothorax most profoundly bilobed, about twice as wide as long, prolonged behind at the middle;" for *X. fossata*, "prothorax 3 times as wide as long, with a large very deep triangular excavation extending from the front margin to the base, which is broadly rounded;" for *X. pressa*, "prothorax transversely oval, fully three times wider than long, broadly but feebly impressed in front, membrane quite visible along the anterior margin between the prothorax and head."

The pronotum of ***hexagonalis*** has no suggestion of bilobation, the anterior border being somewhat arcuate medially and only slightly emarginate within the arcuation, and there is no membrane visible between pronotum and head. This condition approaches most closely that of *pressa* but the width of the pronotum is less than twice as great (9:5) as the length. The v-shaped groove between the elytra extends for their entire length in this species and only one-fourth the length in *pressa*. The discal incision of the elytra is also different.

Pulicipsenius new genus

Limuliform, broad anteriorly, abdomen tapering to a slender apex. Pronotum expansive (fig. 14), anterior and lateral margins rounded to form a large arc, rather strongly deflexed to cover the upper part of the head including the upper half of the eyes. Pronotum evenly convex, transverse, slightly more than one-half as long as broad, not covering the broad, triangular scutellum.

Head deflexed, at right angles to the body, mouth inferior. Head short, strongly transverse, compressed. Vertex (fig. 2) broad and large, feebly convex. Eyes large, prominently extending beyond the general contour of the head. Antennae inserted medial to the eyes, the sides of the head in front of the eyes excavated to receive the first antennal segment. The anterior tentorial pits on the front margin of the head capsule, the anterior arm of the tentorium visible beneath the vertex, appearing as a dark suture (illustrated by broken lines in figure). Postclypeus extremely short; anteclypeus membranous; labrum rather large, feebly sclerotized, anterior border as shown in figure.

Antennae 11-segmented; first segment elongated, compressed; second shorter, subcylindrical; third slender, slightly thicker apically; 4–10 increasing in width, all somewhat compressed, terminal segment ovoidal, apical area membranous.

Mandibles broad basally, apical half slender, toothed medially (fig. 4).

Gular region (fig. 9) unsclerotized or very feebly so; submentum a short transverse sclerite; mentum trapezoidal, rather weakly sclerotized, the sides sinuate, and the anterior margin shallowly emarginate. Postgena lateral to submentum declivous and clothed with a dense vestiture of fine hairs. Prementum composed of a quadrate basal sclerite, the small rounded glossae bearing two conspicuous setae, two large membranous paraglossae, and rather large palpigers. Labial palpi 3-segmented; the second segment more slender than in *Trichopsenius*; the slender third segment bearing at its apex a minute spicule.

Cardo of the maxilla transversely elongated, the posterior border arcuate. Galea and lacinia subequal, the galea expanded somewhat distally and bearing on its flattened apical border a row of long, fine hairs; the lacinia very slender, incurved moderately at apex, the medial border bearing a few fine hairs. The maxillary palpi 4-segmented, slender; the third segment expanded distally; the fourth long, tapering, bearing a minute spicule set in the apex.

Elytra approximately as long as the pronotum, and as wide basally, sides converging a little posteriorly, posterior border emarginate; epipleurae moderate. Winged.

Prosternum less than one-half as wide as the pronotum, short, very slender laterally. Front coxae broad, very much compressed, proximal one-third narrow, articulating with a long curved trochantin.

Mesosternum very short, produced between the oval, middle coxae to meet a similar production of the metasternum. Structure of the metasternum illustrated by figures 15–18 and described in the subfamily characterization.

Front femora broad, flat, nearly as long as the coxae, the ventral surface expanded as moderately broad median plate which disappears proximally. Fore-tibia shorter than femur, sparsely setose, and bearing two rather stout terminal spines, the outer one of which has a row of 6 shorter spines proximal to it. The hind leg is shown in fig. 15, the trochanter very large and nearly oval in outline; femur short and broad; tibia short, stout and bearing a formidable array of large, stout spines.

Tarsi 5-segmented; first 4 segments of anterior tarsus equal, the fifth as long as the 2 preceding together; middle tarsus as long as tibia since the first segment is nearly equal to the last 4 segments; hind tarsus very long, the first segment equal to all of the other segments.

Abdomen strongly tapering apically, the dorsum and venter moderately convex. Paratergites absent. Tergites and sternites of segments 3–7 similar except that the more posterior ones are much narrower; the third sternite longer than the others.

Genotype: *Pulicipsenius acanthoscelis* n. sp.

Pulicipsenius differs from *Trichopsenius* in the following respects: head very much compressed and very short; gena excavated in front of eyes for the reception of the scape; the shape of the labrum; toothed mandibles; the shape of the second segment of the labial palpi; gular region unsclerotized or very feebly so; submentum separated from postgenae; pronotum

much larger, and with front and sides deflexed to cover the upper half of the head; hind tibiae strongly spinose; abdomen slender, conical, strongly tapering apically.

Pulicipsenius acanthoscelis n. sp.
(Figs. 2, 4, 5, 9, 14–18, 28)

Length, 1.75 mm. Uniformly testaceous, antennae flavous. Strongly shining.

Head with 2 setae on vertex between the antennae, and 2 on the anterior margin of the head capsule. Pilosity of labrum as in fig. 2. Head microscopically punctulate, the punctures arranged in pairs.

Pronotum and elytra bearing series of very long, slender, pale, rather stiff bristles in longitudinal rows. The 4 rows of each half of the pronotum composed of 5, 3, 2, 2 bristles, respectively; the 2 anterior ones of the medial row shorter, and the 2 of the marginal row close together near the posterior angles. The 4 rows on each elytron composed of 2, 3, 3, 3 bristles, respectively. The abdominal tergites each have 4 and the sternites 6 bristles on their apical borders. The lateral plates of the ninth segment bearing 4 very long, stout, dark bristles directed posteriorly.

Type locality: Kartabo, British Guiana.

Holotype and 13 paratypes collected from a colony of *Rhinotermes marginalis* (L.), 20-IV-1924 (A. Emerson).

Rhinotermopsenius new genus

General habitus as shown in fig. 13. Head small, deflexed, covered in part by the pronotum, thorax rather large and membranous; the basal segments of the abdomen somewhat swollen, membranous; the apical segments (5–10) more slender, tapering.

Structure of the head very similar to that of *Pulicipsenius*. Antennae inserted medial to the eyes, somewhat removed from the anterior tentorial pits on the front margin of the head capsule. Genae not excavated in front of the eyes. Eyes large, Postclypeus very short; labrum moderately large, apical border strongly arcuate (fig. 1). Gula very feebly sclerotized or entirely membranous, the exact situation being very difficult to determine. Submentum short, transverse. Labium and maxillae very similar to those of *Pulicipsenius* (fig. 9) except that the second segment of the labial palpi is very much more like that of *Trichopsenius* (fig. 11). Antennae (fig. 8) having segments 4–7 longer than those of *Pulicipsenius*. Mandibles bearing a small tooth at middle.

Pronotum moderate in size, trapezoidal in shape, widest at base, not appreciably deflexed apically or laterally. Elytra (fig. 12) moderate in size, sides nearly straight, apex feebly arcuate; epipleurae very small. Associated with the setae are rather large, oval spaces in the elytra, either clear and situated caudad to the setae or brown and surrounding the setigerous puncture. The latter situation prevails with respect to the apically situated setae. Whether these spaces contain gland cells in life is a matter of speculation. Wings present.

Prosternum very short, transverse. Prothoracic coxae long; the slender proximal half articulating with the long, thin trochantin, the distal half thicker, fusiform. Front femora approximating the coxae in length, compressed; tibia slender, shorter than femur, densely and finely setose, bearing 3 slender apical spines and 4 subapical spinules.

Mesothoracic coxae oval; femora compressed, moderate in size, sides straight; tibiae slightly shorter, slender, scarcely broader distally, bearing one long apical spine and several spinules.

Metasternal structure very similar to that of *Pulicipsenius* except that the ventral plates are not as wide. Hind coxae very short; trochanters large, compressed, ovoidal, articulating as in *Pulicipsenius*. Metathoracic legs long, one and one-half times as long as those of *Pulicipsenius*; femora compressed, sides nearly straight; tibiae longer than the femora, gradually enlarged distally, sparsely setose and bearing 3 terminal spines.

Tarsi 5-segmented. Anterior tarsus shorter than tibia, the first 4 segments subequal, the fifth equal to the 2 preceding segments together; middle tarsus longer than tibia, first segment longer than the other four together, fifth equal to the 2 preceding; hind tarsus extremely long, first segment subequal to the other four together, the second as long as the following two, the third longer than fourth, fifth shorter than the two preceding segments together.

Abdomen somewhat physogastric, the basal segments swollen and membranous. The membranous areas of the thorax and abdomen are stippled in the accompanying figure. Male and female genitalia basically as in *Trichopsenius*; the lateral plates of the ninth segment (paraprocts) of the female are very large and stout.

Genotype: *Rhinotermopsenius saltatorius* n. sp.

This genus differs from *Pulicipsenius* in the following respects: the size and structure of pronotum and elytra; the much longer, more slender, more feebly spinose hind legs; the arcuate labrum; the absence of the excavation in front of the eyes; the structure of the second segment of the labial palpus; the physogastric abdomen.

Rhinotermopsenius saltatorius n. sp.

(Figs. 1, 8, 12, 13)

Length, 1.75–2.0 mm. Light reddish brown, abdomen lighter than the thorax and head. Head sparsely and microscopically punctate, the punctures often arranged in small groups. Head bearing 2 setae on vertex medial to antennae and 1 on each side of front margin of head capsule medial to the anterior tentorial pits. Pronotum adorned with 4 longitudinal rows of setae on the disc, each row made up of 5 setae; and with several smaller ones on the lateral border. Vestiture of elytra as figured. Abdominal segments 3–7 with several rows of moderately long, very pale erect setae on both tergites and sternites. Eighth tergite bearing 2 apical setae and a subapical row of 8 pale setae. Lateral plates of ninth segment very stout and strongly setose, the terminal group of setae very long.

Type locality: Kartabo, British Guiana.

Holotype (female) and two paratypes (males) were collected from a colony of *Rhinotermes marginalis* (L.), 20-IV-1924 (A. E.).

Genus **Termitopsenius** Wasmann

Wasmann: 1902, p. 4.
Silvestri: 1903, p. 201, pl. VI, figs. 283, 284.

A single species, *T. limulus* Wasm., was collected from the nest of *Neocapritermes opacus* (Hagen) at Posados, Misiones, Argentina. The close relationship between this genus and *Trichopsenius* is clearly evident from Silvestri's figures. Since Wasmann originally assigned this genus to the Cephaloplectinae, it has been included with that group (Bernhauer, Coleopterorum Catalogus 67, 1916; Scheerpeltz, ibid, 129, 1933), even though it bears no relationship to *Cephaloplectus* Sharp.

It seems as if this genus resembles *Pulicipsenius* most closely in general habitus since it is limuliform, has the deflexed head inserted in the broad, disc-shaped pronotum so that it is invisible from above, and has a narrow, acutely conical abdomen. As Wasmann's description was very general, it is impossible to characterize the genus very well. If the antennae are 10-segmented as described, this genus differs from the other American genera and agrees with the Sumatran genus *Hamitopsenius*. The hind legs are not strongly spinose as in *Pulicipsenius*.

Genus **Hamitopsenius** Wasmann

Wasmann: 1916, p. 198, pl. IV, fig. 17; pl. V, fig. 17.

A number of specimens of *Hamitopsenius caudatus* Wasm. was collected from the nest of *Amitermes* (*A.*) *dentatus* (Havil.) in Tandjong Slamat, Sumatra. Wasmann's figures indicate very clearly the affinities of this genus with the new world genera. The description and figures are too general, however, to allow for more than a recognition of basic similarities. This species is the largest of the group, measuring 6.5 mm. in length. The antennae are said to be 10-segmented.

Subfamily **Aleocharinae**

Termitohospini new tribe

On the basis of the peculiar structure of the head, it is not possible to associate the five new genera described herein with any of the tribes into which the Aleocharinae is divided. The

present tribal classification of the subfamily is an artificial one based largely on the number of segments of the tarsi, palpi and antennae. Under this arrangement, these genera would be included with the Bolitocharini, to which they do not seem to be very closely allied. It may be desirable eventually to separate this group from the Aleocharinae, as these species present some distinctive features, but it seems best at present to include them in that subfamily.

The most important tribal characteristics are as follows:

Minute, limuloid species; known only as inquilines in the nests of termites.

Head and ventral parts of thorax concealed (or nearly so) from dorsal view by the expansive, shield-shaped pronotum and the broad elytra; the broad semicircular anterior margin of the body formed by the continuously arcuate apical and side margins of the pronotum. Abdomen narrower than the elytra basally and tapering behind to a slender, acute apex.

Head strongly deflexed, the long axis of the head at right angles to, or forming an acute angle with, the long axis of the body; mouth inferior. Head (fig. 37) broadly and deeply excavated medial to the eyes; the antennae inserted under the superior margin of this fossa in which rests the scape of the antennae; inner margin of the fossa carinate. From the position of the anterior tentorial pit at the median inferior angle of the large fossa and the insertion of the antenna under its superior margin, it appears that the head has elongated in such a way as to separate the antennal insertion from the point of union of the anterior tentorial arm with the head capsule, and to thus form the huge fossa between them. This, apparently, is a very unusual situation in the Staphylinidae for Blackwelder (1936) concludes, after his comparative morphological studies of the family, that the anterior arms of the tentorium are always associated closely with the antennal insertions.

Postclypeus broad, extending laterally in front of the fossae to meet the genae anterior to the eyes. Frontal sutures absent. Antennae 11-segmented, geniculate, quite variable in form. Eyes usually large, but greatly reduced in *Termitosocius*. Mandibles slender, apex acute; left mandible usually feebly dentate near middle; right mandible, and sometimes the left, microscopically crenulate.

Cardo of maxilla elongated transversely; galea and lacinia subequal in length; the slender lacinia acutely incurvate at apex and with inner border dentate or spinulose; and the slender galea rather densely pilose at its rounded apex. Maxillary palpi 4-segmented.

Gula broad and moderately long, continuous with the rather large submentum; mentum trapezoidal, the anterior border emarginate and the anterior angles produced on each side of the prementum. Prementum composed of a quadrate basal sclerite, partially sclerotized palpigers, slender ligula and inconspicuous paraglossae. Labial palpi 3-segmented, elongated, slender, filiform.

Prosternum short, transverse. Mesosternum moderate, only slightly

produced between the middle coxae. Metasternum very short behind the middle coxae and not extending forward between them.

Anterior coxae robust, somewhat conical, ventral side convex. Middle coxae flat, oval in outline, contiguous. Posterior coxae transverse, not expanded medially over the trochanters. Legs moderately long, the femora compressed, and the slender tibia cylindrical; the tibiae sometimes densely setose or bearing terminal spines. Tarsi 4, 4, 5 segmented.

Abdominal segments 3–7 margined dorsally by 2 paratergites on each side. The eighth segment composed of a generalized tergite and sternite in both sexes. The sclerites of the abdomen caudal to the eighth segment quite similar in appearance in both sexes although if interpreted according to previous accounts would be derivatives of different segments. The ninth tergite of the male (fig. 38) almost completely divided medially, while the lateral plates (usually regarded as derivatives of the ninth segment) are connected by a narrow dorsal bridge in front of the ninth tergite and are produced somewhat on the ventral side into slender, anteriorly directed processes. The ninth male sternite is small and unmodified. Terminal segments of the female abdomen shown in figs. 44 and 45. The divided sclerite caudal to the eighth tergite is interpreted as the proctiger (usually regarded as the tenth tergite), while the lateral plates, which are connected by a dorsal bridge in front of the proctiger as in the male, are interpreted as the paraprocts (usually regarded as derivatives of the ninth tergite). The paraprocts bifurcated ventrally. On the ventral side of the apex of the abdomen there is a small, undivided feebly sclerotized structure, setose in part, which is difficult to interpret (fig. 45).

The median lobe of the male aedeagus composed of a bulbous proximal portion and a more slender distal tube terminating in a blunt dorsal projection. Figure 46 illustrates the median lobe with the spinulose inner sac everted from the median orifice and the flagellum extended. The lateral lobes, also shown in the figure, articulate with posterior dorsal part of the bulb. They are partially sclerotized, partially membranous, the distal half markedly attenuated and curved at tip.

Termitohospes new genus

Minute species, limuloid in general habitus. Anterior parts broad, abdomen slender, conical, apex acute.

Head covered by pronotum, invisible from above; so strongly deflexed that the mouth is inferior and the long axis of the head forms an acute angle with the long axis of the body. Vertex (fig. 37) broadly and deeply excavated medial to the eyes for the reception of the first antennal segment; the inner rim of these fossae carinate. Antennae inserted under the superior margin of the fossae at some distance from the anterior tentorial pits. Vertex between the fossae narrow, the postclypeus widening distal to the fossae to meet the genae laterally in front of the eyes. Anteclypeus membranous; labrum weakly sclerotized, transverse, apical border feebly emarginate.

Eyes large, approximating the size of the adjacent fossae. Mandibles slender; right mandible simple except for a very feeble crenulation of

the medial border distal to the middle; left mandible bearing a low, blunt tooth immediately distal to the middle.

Antennae 11-segmented, geniculate; the scape large, ovoid, bearing two conspicuous setae medially; the second segment somewhat conical. Segments 3–10 transverse, gradually increasing in width distally; terminal segment large, ovoidal, apical portion somewhat membranous.

Mouthparts illustrated by fig. 30. Gula broad and rather short, 3 times as broad as long. Submentum continuous with gula, considerably broader apically, anterior border slightly sinuate. Sides of mentum converging apically; anterior border deeply and broadly emarginate, anterior angles produced. Prementum composed of a rather weakly sclerotized, quadrate, basal piece bearing the moderately sclerotized palpigers anteriorly. Glossae forming a slender ligula; paraglossae inconspicuous. Labial palpi 3-segmented, long and slender; basal segment considerably longer than the last 2 combined; second longer than the third.

Cardo of maxilla elongated transversely, articulation with postgena covered by submentum. Galea and lacinia subequal in length; lacinia slender, tapering apically to an incurved hook, the medial border bearing a comb of setae. Galea narrow, apex clothed with a few fine hairs. Maxillary palpi 4-segmented, first very small; second slender, broader apically; third long and thin, fusiform; fourth slender, attenuated distally.

Pronotum very large, approximately twice as wide as head or prosternum; prolonged anteriorly over head and covering scutellum and base of elytra posteriorly; apex and sides deflexed somewhat; anterior and lateral borders broadly arcuate, together forming the large semicircular anterior margin of body; posterior border sinuate. Elytra large, as broad as pronotum and about four-fifths as long; the posterior margin rather deeply emarginate medially. Elytral epipleurae rather broad basally, narrowing posteriorly to disappear before apex. Wings present.

Prosternum short, transverse. Mesosternum moderately long, with a short acute process extending posteriorly between the middle coxae; bearing a small blunt tubercle medially. Metasternum very short medially, not extending forward between middle coxae; with 2 strong setae near middle of posterior border between hind coxae.

Anterior coxae robust, somewhat conical in shape, ventral surface convex; trochanters small; front femora short, about as long as the coxae, compressed; tibiae short and slender, bearing a strong terminal spine and several smaller subterminal spinules, setose. Middle coxae oval, flattened, contiguous; femora of middle leg compressed, narrower distally; middle tibiae cylindrical, shorter than femora, bearing 2 terminal spines, and 1 subapical seta. Hind coxae broad and flat, more than twice as long as the metasternum at middle; not prolonged ventrally as a lamina over trochanters and femora. Tarsi 4, 4, 5 segmented; first 3 segments of fore and middle tarsi subequal, and the fourth somewhat longer; hind tarsi moderately long, the first 4 segments decreasing gradually in length; the fifth longer than the 2 preceding together.

Abdomen gradually narrowed posteriorly to an acute apex. Dorsum of abdominal segments 3–7 margined on each side with 2 narrow tri-

angular paratergites. Eighth abdominal segment composed of generalized tergite and sternite. Terminal male segments as illustrated in fig. 38 and described in the tribal characterization. Female genital segments (figs. 44, 45) described in tribal account. Aedeagus of male similar to that of *Termitosocius* (fig. 46).

Genotype: *Termitohospes miricorniger* n. sp.

Termitohospes miricorniger n. sp.
(Figs. 33, 37, 44, 45)

Length, 1.25–1.5 mm. Uniformly testaceous, strongly shining.

Antennae (fig. 33) geniculate; scape ovoidal, bearing 2 conspicuous bristles; second segment conical; third short, produced medially and bearing a long stout bristle; segments 4–10 transverse, increasing in length and breadth apically; terminal segment as long as the 3 preceding segments together, apex membranous.

Vestiture of the head as shown in fig. 37; the sparse, ventrally directed hairs of the vertex shorter on the upper part of the head. Distal to each setigerous puncture is a row of from 1–4 minute punctures; the more apically situated groups usually are composed of 3 punctures but the number diminishes to 1 in front of the more dorsally situated setae.

Pronotum and elytra minutely punctulate and microscopically pubescent; pronotum with 2 short setae on the lateral margin. Tergites sparsely pilose throughout and with a row of recumbent light hairs on the posterior border but not setose except for several very small setae on the divided ninth tergite. Sternites 3–6 with a pair of setae on the posterior margin near each side and a third seta more medially. Eighth sternite bearing 8 setae, 2 on the apical border, 4 in a subapical row and 2 on lateral margins a short distance in front of these. All sternites densely clothed with recumbent hairs.

T. miricorniger was collected from seven colonies of two species of *Nasutitermes*. The holotype and 12 paratypes were collected with four colonies of *Nasutitermes* (N.) *ephratae* Holm. at Kartabo, British Guiana, 23, VII, 1920 (A. E.), 21, IX, 1920 (A. E.), 19, III, 1924 (A. E.) and 5, VIII, 1926 (L. H. B.) Fifteen paratypes were collected from two colonies of *Nasutitermes* (*N.*) *costalis* Holm. at Kartabo, B. G., 7, VIII, 1920 (A. E.), and 11, VIII, 1920 (A. E.); and five paratypes were collected from a colony of the same host at Manzanilla, Trinidad, 19, VIII, 1924 (A. E.).

Termitohospes guianae n. sp.
(Fig. 34)

Length, 1.25–1.5 mm. Uniformly testaceous, strongly shining. Very similar to *T. miricorniger* in nearly every respect except antennal structure. The antennae (fig. 34) differ considerably in the structure of the intermediate segments; 3–6 not short and compressed as are those

of *miricorniger*. The third segment is not produced medially yet bears the long seta similar to that of the much compressed third segment of *miricorniger*. Vestiture similar to that of *miricorniger* but differing in that tergites 3–8 bear a seta on the posterior margin near the side, and sternites 3–6 do not have the pair of setae near the middle of the posterior margin (except on the fifth in some cases).

Type locality: Kartabo, British Guiana.

The holotype and 8 paratypes from one colony of *Nasutitermes* (*N.*) *surinamensis* Holmg., 21, VIII, 1920 (A. E.), and one paratype from another colony of the same species of termite, 2, VIII, 1926 (L. H. B.)

Termitohospes panamensis n. sp.

Length, 1.25 mm. Testaceous, shining.

Antennal structure similar to that of *guianae* except that the scape is longer and more slender, being nearly equal to the 4 following segments together while in *guianae* the scape is not longer than the second and third segments together. The vestiture of this species is distinctive. The pronotum with setae arranged as follows: 2 on the front margin and 5 on each lateral margin (the middle 3 much stronger). The lateral elytral margin with 3 strong setae. Tergites 3–6 bearing 4 setae on the posterior margin, seventh not setose, eighth with 2 small setae on apical margin and 2 subapical ones. Sternites 3–7 with 6 setae on the posterior border, the middle pair in each case rather weak except on the seventh where these setae are very strong; eighth sternite as in *miricorniger*.

Type locality: Barro Colorado Island, Canal Zone.

The unique holotype was collected from the nest of *Nasutitermes* (*N.*) *columbicus* (Holm.), 6, IX, 1935 (A. E.).

Termitocolonus new genus

With the general habitus of *Termitohospes*, broad anteriorly and tapering posteriorly. Head deflexed, covered by the large pronotum; head considerably smaller in proportion to the body than in *Termitohospes*. The fossae medial to the eyes broad and deep, the vertex between them very narrow; postclypeus expanding laterally in front of fossae to meet genae in front of the eyes. Eyes prominent, coarsely facetted, larger than the adjacent fossae. Mandibles moderately broad proximally, gradually and evenly tapering to blunt apices; right mandible feebly crenulate, left mandible bearing a blunt tooth distad to the middle and then very slightly crenulate. Labrum nearly membranous, structures not clearly seen.

Antennae 11-segmented, geniculate, very much elongated, 3 times as long as that of *Termitohospes*, and very different in structure (fig. 32). Scape of antenna fusiform; the remaining segments subcylindrical, 3–10 only slightly variable in length; the terminal segment shorter, with rounded apex. The second and third segments bearing 4 very conspicuous apical setae, the others moderately setose.

Gular region rather large, more than half as long as broad; the submentum shorter than gula, broader apically. Mentum with sides slightly concave, the anterior border emarginate, anterior angles produced into acute blunt processes. Labial palpi 3-segmented, slender, second and third segments small, slightly narrower than the first. Ligula larger than in *Termitohospes*.

Maxilla with transversely elongated cardo; subequal galea and lacinia and 4-segmented palpus. Lacinia terminating in slender incurvate hook; the medial border bearing a comb of setae; the galea with apical group of fine hairs.

Thorax and abdomen very similar in structure to those of *Termitohospes*. Abdomen somewhat conical as a whole, tapering to a narrow apex, the dorsum and venter rather convex. Ninth tergite of male divided into 2 rather heavy, but slender, styliform structures.

Genotype: *Termitocolonus ericiogaster* n. sp.

This genus differs from *Termitohospes* primarily in the structure of the antennae and in the array of macrochaetae on the abdomen.

Termitocolonus ericiogaster n. sp.

(Figs. 32, 39)

Length, 1.5 mm. Uniformly flavotestaceous in color.

Head and thorax without erect setae; the head, however, with scattered pale recumbent hairs; pronotum and elytra sparsely and microscopically punctulate and pubescent. In sharp contrast to the head and thorax, the abdomen bristles with a rather formidable array of unusually long setae. The basal one-sixth of most of these setae is stout and dark, with the distal five-sixths attenuated and pale, although some of those of the proximal ventral sclerites are uniformly thin and pale. These setae, which are for the most part about one and one-half times as long as the abdominal segments, are arranged as follows: 4 on the posterior margins of tergites 3–6; 2 on the apical margin of the eighth tergite and 2 on its lateral margin near the middle; 3 on each half of the divided ninth tergite; 3 on each lateral plate of the ninth segment; 10–12 on each of the first 4 sternites (3–6); 8 on the seventh sternite; and 2 apical and 6 in a subapical row on the eighth sternite.

Type locality: Kartabo, British Guiana.

Holotype and 10 paratypes collected from a single colony of *Velocitermes beebei* Emerson, 9, X, 1920 (A. E.).

Termitosodalis new genus

Having the general habitus of *Termitohospes* from which it differs primarily in antennal structure. The head is deeply excavated medial to the eyes and the antennae are inserted under the superior margin of this fossa. Head set in the pronotum so as to be concealed from view when observed from above, deflexed, mouth inferior, axis of the head at right angles to that of the body. Mouthparts very similar to those of *Termitohospes*.

Antennae very long (three times as long as those of *Termitohospes*), geniculate; scape only moderately long, somewhat broader apically; second segment smaller, cylindrical; third segment elongated, subcylindrical, equal to the first 2 segments together; segments 4–10 cylindrical, subequal, with the fifth a little longer than the others; terminal segment small, ovoidal.

Thorax and abdomen similar to those of *Termitohospes*; the eighth male tergite, however, being rather deeply incised at apex.

Genotype: *Termitosodalis barticae* n. sp.

The antennae of this species approximate those of *Termitocolonus* in length but differ considerably in structure. The abdomen of this species does not approach that of *Termitocolonus* in its chaetotaxy.

Termitosodalis barticae n. sp.

(Fig. 36)

Length, 1.5 mm. Uniformly dull brown in color.

Pronotum, elytra and abdomen densely covered with a vestiture of fine white hairs. Pilosity of the pronotum as follows: 3 somewhat irregular longitudinal rows of setae on each half of the pronotal disc, 2 comprising the inner row, 2 the middle row and 3 the outer submarginal row. These rows are continued on to the elytra as 1 inner, 2 middle and 2 outer bristles. Tergites 3–6 bearing 4 stout, rather long setae in submarginal rows, seventh without setae, eighth tergite adorned with a basal pair and 1 on each side of the apical incision. The third sternite with 6 erect setae and a number of long apical recumbent hairs; sternites 4–6 bearing 8 setae in submarginal rows; seventh sternite free of setae; eighth adorned with 2 near apex and 6 in a transverse row near the middle of the sclerite.

Type locality: Kartabo, British Guiana.

Described from a unique holotype (male) collected from the nest of *Velocitermes beebei* Emerson, 9, X, 1920 (A. E.).

Termitosocius new genus

Head completely covered by the pronotum, strongly deflexed, the long axis at right angles to that of the body. Head very long and slender, nearly triangular in outline, the long attenuated mouthparts forming the apex of the triangle. Dorsum (anterior surface) similar to that of *Termitohospes* in basic structure, differing in that the fossae medial to the eyes are smaller and shallower, and the labrum is more elongated, more strongly sclerotized and more conspicuously setose. Eyes very much reduced in size, composed of only 12–15 facets. Mandibles elongated, rather slender; proximal portion only moderately wide, sides tapering gradually to a blunt, slightly incurved apex; medial border of right mandible feebly crenulate for some distance distad to the middle; left mandible toothed near middle, then with a slight suggestion of crenulation.

Antennae 11-segmented (fig. 35), geniculate; scape ovoidal; second segment about three-fourths as long as scape, nearly cylindrical; third segment slender, shorter, also nearly cylindrical; fourth subcylindrical, longer than wide; 5–10 transverse, gradually increasing in width, terminal segment somewhat membranous apically.

Labium and maxilla (fig. 31) are remarkably elongated structures extending beyond the other parts of the head; the dentate, heavily sclerotized lacinia extending beyond the mandibles are easily mistaken for the latter upon superficial examination.

Labium similar to that of *Termitohospes* in general structure. Submentum expanded laterally over the medial half of the cardo, the anterior angles of the mentum long and slender and bearing very long setae. Prementum composed of a large basal sclerite, palpigers bearing the much elongated, filiform 3-segmented palpi, a small ligula, and inconspicuous paraglossae.

Galea and lacinia subequal in length; the long, attenuated, heavily sclerotized lacinia with the medial border dentate; the very slender galea terminating as a small hook and bearing a small tuft of fine hairs. Maxillary palpi 4-segmented, closely resembling those of *Termitohospes*.

Prosternum short, transverse. Anterior coxae long; anterior femora shorter than coxae, compressed; anterior tibiae shorter than femora, slender, inner surface densely spinulose, with 2 heavy terminal spines.

Mesosternum moderately long, a short blunt process extending for a short distance between the middle coxae, and bearing a very low blunt tubercle medially. Middle coxae flat, oval in outline, large; middle femora compressed, narrower than coxae and not much longer, sparsely pilose; tibia shorter than femur, slender, apical half densely setose, bearing two large terminal spines and two short subapical ones.

Metasternum very short; hind coxae transverse; hind femora moderately long and slender; hind tibiae slender, as long as femora.

Tarsi 4, 4, 5 segmented. First 3 segments of fore and middle tarsi subequal, the fourth longer. The first 4 segments of the hind tarsi subequal, the fifth equal to the 2 preceding together.

Abdomen tapering gradually apically, segments 3–7 approximately equal in length, the eighth longer. The abdominal margin formed by the paratergites narrower apically, the inner rectangular paratergites much broader than the slender outer ones. The terminal abdominal segments of the male are indicated in figure 38, and those of the female are similar to those of *Termitohospes* (fig. 44, 45). Aedeagus of male illustrated by fig. 46. The lateral lobe is stippled in the figure, the more heavily sclerotized areas more densely so.

Genotype: *Termitosocius microps* n. sp.

Termitosocius microps n. sp.

(Figs. 31, 35, 38, 46)

Length, 1.75 mm. Uniformly flavous in color, shining.

Vertex, clypeus and labrum clothed with semierect, yellow hairs. Pronotum and elytra very minutely and sparsely punctulate and pubescent. Pronotum bearing setae arranged as follows: 3 longitudinal rows on each half, the inner row of 3, the middle row of 5, the outer,

marginal row of 5. These rows are continued on the elytra, 2 comprising the inner row, 2 the middle row and 1 on the lateral margin. The lateral margin of the elytra bearing also a comb of about 10 moderately long yellow hairs.

Tergites 3–6 of the abdomen with 4 stout, black setae on the posterior border; eighth tergite bearing 2 apical and 2 subapical setae; each half of the divided ninth tergite with 4 and the lateral plate of the ninth segment adorned with 3 setae. Sternites 3–8 bearing 6 black setae on the apical margin, the ninth sternite with 2 setae.

Type locality: Kartabo, British Guiana.

Holotype and five paratypes collected from a colony of *Nasutitermes* (*N.*) *octopilis* Banks, 30, VI, 1920 (A. E.) and one paratype from another colony of the same host species, 24, IV, 1924 (A. E.).

Paratermitosocius new genus

Most closely related to *Termitosocius*. Head deflexed so as to rest in a vertical plane, but not concealed by the pronotum. The anterior border of the pronotum is truncate so that a small portion of the head is visible from above.

Mouthparts very similar to those of *Termitosocius*. The head is shorter, broader and the vertex is more convex than in *Termitosocius* but is otherwise similar. Eyes large, approximating the size of the fossae medial to them.

Antennae 11-segmented, geniculate; scape similar to that of *Termitosocius*, but the second segment more robust and thickened slightly subapically; the third segment subcylindrical; segments 4–10 longer than wide, nearly cylindrical; terminal segment ovoidal.

Pronotum moderately large, anterior border truncate; sides gradually and evenly narrowed apically; basal border bisinuate. Thorax and abdomen otherwise similar to those of *Termitosocius*.

Genotype: *Paratermitosocius vestitus* Mann.

This genus differs from *Termitosocius* in having the smaller pronotum truncate apically so that the head is visible from above, in having large eyes, and in the form of the antennae. Segments 5–10 of the antennae are longer than wide while those of the antennae of *Termitosocius* are transverse and somewhat compressed, segments 9 and 10 being nearly twice as wide as long.

Paratermitosocius vestitus Mann

Mann: (*Perinthus vestitus*), 1923, p. 337.

Length, 2.0 mm. Brown, rather dull. Pronotum and elytra rather densely clothed with a conspicuous vestiture of pale hairs. The lateral margin of the pronotum bearing 4 moderate setae, and the elytral margin 3 longer, stouter setae. Tergites with 1 inconspicuous seta near

lateral margin of the posterior border; sternites 3–7 with 2 setae on the apical border near the side; the eighth sternite with 2 apical, and 4 subapical setae grouped in pairs near the lateral border. Abdomen densely clothed with pale semierect fine hairs.

The specimens upon which Mann based *Perinthus vestitus* were collected at Kartabo, British Guiana, from the nest of *Nasutitermes* (*N.*) *octopilis* Banks by Alfred Emerson. It seems clear, after examination of the holotype in the U. S. National Museum, that *vestitus* is not closely allied to the genus *Perinthus*, to which it bears a strong resemblance, but is related to the species herein regarded as sufficiently distinct as to comprise a new tribe. The head and mouthparts are very distinct from those of *Perinthus*.

Genus **Callopsenius** Wasmann

Wasmann: (*Eupsenius*), 1902, p. 5.
Silvestri: (*Eupsenius*), 1903, p. 202, pl. VI, figs. 285, 286
Wasmann: Zool. Jahrb., Suppl. 7, 1904, p. 679.

One species of the genus, *C. clavicornis* Wasm., is known; that was collected from the nest of *Heterotermes longiceps* Snyder (=*Leucotermes tenuis* Hag.) near Tacurupucu, Paraguay. While this genus is generally associated with the Cephaloplectinae it certainly is not allied with *Cephaloplectus*. Although it is not possible to decide its true relationships without examining the beetle, there are a number of features which suggest relationship to this group. The form of the body, the deflexed head, the deep fossae medial to the eyes, the insertion of the antennae under the superior margin of this fossa, the broad pronotum with semicircular front margin, and flat, acuminate abdomen are suggestive features. Even the antennae, which were described as being 10-segmented, are not unlike those of several species of this group.

Subfamily **Aleocharinae**

Tribe **Termitonannini**

This tribe was established by Fenyes in his work on the Aleocharinae in the Genera Insectorum (1918–21) for two termitophilous genera, *Termitonannus* Wasm. and *Timeparthenus* Silv., and characterized as follows: "Maxillary palpi 4-jointed. Ligula bilobed. Labial palpi 3-jointed. Antennae 10-jointed. Tarsi 4, 4, 5 jointed. Both genera belonging to this tribe are guests of termites." It is clear from the descriptions that

these two genera are not very closely allied, and Fenyes later (Bull. Mus. Comp. Zool. 65, 1921, p. 34) proposed a separate tribe, the Timeparthenini, for the latter genus.

Termitonannus was established by Wasmann (1902, p. 2) for three small species of aleocharines collected from nests of *Anoplotermes* in southern South America. *T. major* Wasm. was collected with *A. pacificus* Mull. in Paraguay (Tacurupucu), *T. silvestri* Wasm. with *A. meridianus* Emerson (=*morio* Hagen) in Argentina (S. Catilinas, B. Aires), and *T. schmalzi* Wasm. with *A. ater* Hagen (?) in Brazil (Joinville, Sta. Catharina). The original descriptions are weak and determinations of species would be almost impossible were it not for illustrations by Silvestri (1903, pl. VI, figs. 274–282).

The two new Panamanian species of *Termitonannus* and the British Guiana species of the new genus *Termitocomes* described herein were all collected from colonies of *Anoplotermes* and extend considerably the range of this group of aleocharines. The most important tribal characteristics may be summarized as follows:

Small limuloid species; broadly rounded anteriorly, widest at the base of the pronotum; abdomen conical, strongly tapering behind.

Head short, markedly transverse. Vertex abruptly deflexed anterior to the eyes and forming an arcade slightly overhanging the concave postclypeus medially and the antennal fossae laterally. The antennae inserted in deep fossae beneath the arcade just medial to the eyes. The proximal half of the first antennal segment is not visible from above. Antennae 10-segmented (fig. 43), the fourth and fifth segments extremely short; segments 6–10 cylindrical in *Termitonannus*, compressed in *Termitocomes*. Eyes large, coarsely facetted in *Termitonannus*. Mandibles simple.

Gula broad and moderately long. Galea long and slender, exceeding the lacinia in length. Ligula very slender, not bilobed (at least in the species at hand). Labial palpi 3-segmented; the third segment of *Termitonannus* bearing a small terminal spicule. Maxillary palpi 4-segmented; the fourth segment of *Termitonannus* slender, bearing a terminal spicule; the fourth segment of *Termitocomes* very much enlarged, conical, and without spicule.

Pronotum large, but not expanded over head. Mesosternum and metasternum very short in front and behind the middle coxae, respectively. All coxae large; the anterior ones flat above, strongly convex below, elliptical in outline; middle coxae flat, ovoidal, scarcely separated by a very fine process of the metasternum; hind coxae long and broad, rather robust medially. Tarsi 4, 4, 5 segmented.

Termitocomes new genus

Head short, transverse, and only a small part of the occiput is covered by the pronotum. Vertex smooth, moderately convex, abruptly

and strongly deflexed in front of the eyes, forming a rounded frontal arcade. The antennae inserted in broad and deep fossae medial to the eyes in this perpendicular part of the vertex. From above, the antennae appear to arise from under frontal ridges of the head. The scape is set so deeply in this fossa that the basal half is concealed from above. Superior and medial borders of antennal fossae strongly carinate, the carina disappearing on the postclypeus. Mandibles simple. Labrum moderate in size.

Antennae 10-segmented, structure basically as in *Termitonannus*, except that most of the segments are compressed and not cylindrical. First segment moderately long, subcylindrical, somewhat arcuate; second nearly as long as the first, third small, conical; fourth and fifth very short, strongly transverse; 6–9 strongly compressed, longer than wide; tenth segment about as long as the 2 preceding together, tapering to narrow, rounded tip.

Gula rather large, transverse, basal angles somewhat produced behind postgenae; submentum short, strongly transverse; mentum trapezoidal, apex feebly emarginate. Basal part of prementum and palpigers rather large; ligula moderately long, slender, not bilobed. Labial palpi 3-segmented, similar to those of *Termitonannus* except for the absence of the terminal spicule. Gala and lacinia differing somewhat from *Termitonannus* (fig. 41), the galea unusually long, the distal part slender. Maxillary palpi 4-segmented (fig. 40), terminal spicule absent, fourth segment large, conoidal, differing notably from that of *Termitonannus*.

Pronotum large, strongly and evenly convex; anterior margin very feebly emarginate, as wide as the head; sides diverging posteriorly so that the base of the pronotum is nearly twice as wide as the apex (5 : 9). The length of the pronotum is a little more than half the greatest width. Basal border bisinuate.

Elytra as wide as the base of the pronotum, shorter than the pronotum, apex slightly concave; epipleurae broad at base, narrower apically.

Prosternum short, transverse. Anterior coxae large, somewhat ellipsoidal with the upper surface flat and under surface strongly convex; rather densely pilose and bearing a large black seta on ventral surface. Mesosternum very short, feebly produced between the large oval middle coxae. Middle coxae flat ventrally. Metasternum extremely short behind the middle coxae, and very thinly produced between coxae. Metepimeron and metepisternum large. Metasternum bearing 2 conspicuous black setae medially. Hind coxae very large, the rather long medial portion robust, excavated laterally for the reception of the femora; medial portion densely clothed with long hairs. Hind trochanters large, narrowing to a rounded tip apically.

Anterior femur as long as coxa, compressed, widest proximally; tibia shorter, with a terminal group of spines and a few on the outer margin of the distal half. Hind femur compressed, broadest at middle; hind tibia slender, longer than femur, setose medially, devoid of spines.

Tarsi 4, 4, 5 segmented; the basal and terminal segments of the fore and middle tarsi twice as long as the others; the hind tarsi seven-eighths as long as the tibiae, and having the first segment much elongated, segments 2–5 subequal, the fourth being perhaps a little shorter.

Abdomen conical, tapering strongly at apex. Sides with a pair of paratergites. Seventh and eighth tergites of male much longer than the others, their apical borders arcuate; the eighth sternite also elongated. Ninth tergite of male divided into two long slender styliform processes.

Genotype: *Termitocomes wasmanni* n. sp.

Termitocomes differs from *Termitonannus* in the following respects: The five distal segments of the antennae are strongly compressed instead of being cylindrical; the galea is much longer and the lacinia somewhat different; the fourth segment of the maxillary palpi is large and conical; and the palpi lack terminal spicules.

Termitocomes wasmanni n. sp.

(Figs. 40, 41)

Length, 2.6 mm. Testaceous in color, strongly shining. Arrangement of the setae on the pronotum as follows: 2 setae on the apical margin near the side, 4 on each lateral margin, and 4 comprising a transverse row on the disc. The elytra with 4 on the disc of each elytron, and 2 on the lateral margins (as indicated by setigerous punctures in the unique specimen). The abdomen bearing long, stout, black setae with pale tips as follows: 1 on lateral margins of the third tergite near apex; 6 in subapical rows on the tergites 4–6; a transverse row of 6 at middle of seventh tergite, 6 in a basal row and 4 in a subapical row on the eighth tergite; 1 on the lateral margins of the third sternite; subapical rows of 8 on the fourth and fifth sternites; 6 on the sixth sternite; 4 on the seventh sternite and a medial transverse row of 4 on the eighth sternite.

Holotype (male) collected at Kartabo, British Guiana, 27, VII, 1926 (L. H. B.) from the nest of *Anoplotermes* (*Speculitermes*) *silvestrii* Emerson.

Termitonannus setosus n. sp.

(Figs. 42, 43)

Length, 1.2 mm., maximum width, 0.6 mm. Testaceous, highly polished; mouthparts, legs, base and apex of antennae pale yellow. Head short, strongly transverse. Antennae inserted in large fossae under an arcade of the vertex which is strongly deflexed between these fossae. Antennae 10-segmented, cylindrical, relative lengths of the segments shown in fig. 43; the terminal segment almost as long as the three preceding segments combined. Maxilla illustrated in fig. 42; labial and maxillary palpi with slender spicules set in the terminal segments.

Anterior border of pronotum straight; side borders arcuate; posterior border sinuate; pronotum much wider posteriorly, all angles rounded. Pronotum bearing 1 very long erect seta above each eye and a smaller one adjacent to it, and 3 setae on the lateral margin (the middle one submarginal). Elytra adorned with 3 conspicuous setae on the lateral margin, 1 smaller seta on the posterior border, and 1 on the disc just behind the pronotum.

Abdomen adorned with very long setae; dorsum bearing 4 longitudinal rows of long, stout, black bristles, the marginal rows beginning

on the third tergite, the 2 middle rows beginning on the fifth tergite; venter bearing 6 longitudinal rows, the 4 inner rows beginning on the fourth sternite. Abdomen also clothed with pale, recumbent hairs.

Type locality: Barro Colorado Island, Canal Zone.

The holotype and one paratype were collected, 6, IX, 1935, from a colony of *Anoplotermes* n. sp. (No. 152b, collection of A. E. Emerson).

Termitonannus gatuni n. sp.

Length, 1.0 mm., width 0.5 mm. Flavotestaceous, highly polished. This species differs from *setosus* primarily in the arrangement of the setae. Pronotum with 3 very feeble marginal setae and the elytra bearing one seta at their outer apical angles. Sixth tergite with a small seta on the lateral margin; seventh an apical row of 6 small setae; eighth 2 transverse rows of 4 setae, and each half of the ninth bearing 2 stout terminal bristles and one midway from the base. The lateral plates of the ninth bearing 3 stout bristles each. The setae of the dorsum are much stouter on the more apical segments of the abdomen. Sternites 3–8 bearing one stout seta at the outer apical angles and 4 fine erect setae along the apical border. Terminal antennal segment a little longer than the 2 preceding segments combined.

Type locality: Barro Colorado Island, Canal Zone.

The unique holotype was collected, 6, IX, 1935, from the same colony of *Anoplotermes* n. sp. (No. 152b, collection of A. E. Emerson) as the preceding species.

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EXPLANATION OF PLATES

Plate I

Fig. 1. *Rhinotermopsenius saltatorius*. Labrum. 2. *Pulicipsenius acanthoscelis*. Front view of head. 3. *Trichopsenius depressus*. Front view of head. 4. *P. acanthoscelis*. Right mandible. 5. *P. acanthoscelis*. Antenna. 6. *Xenistusa hexagonalis*. Antenna. 7. *T. depressus*. Antenna. 8. *R. saltatorius*. Antenna. 9. *P. acanthoscelis*. Underside of head. 10. *X. hexagonalis*. Underside of head. 11. *T. depressus*. Labial palpus. 12. *R. saltatorius*. Elytron. 13. *R. saltatorius*. Lateral view, membranous areas stippled. 14. *P. acanthoscelis*. Lateral view.

Plate II

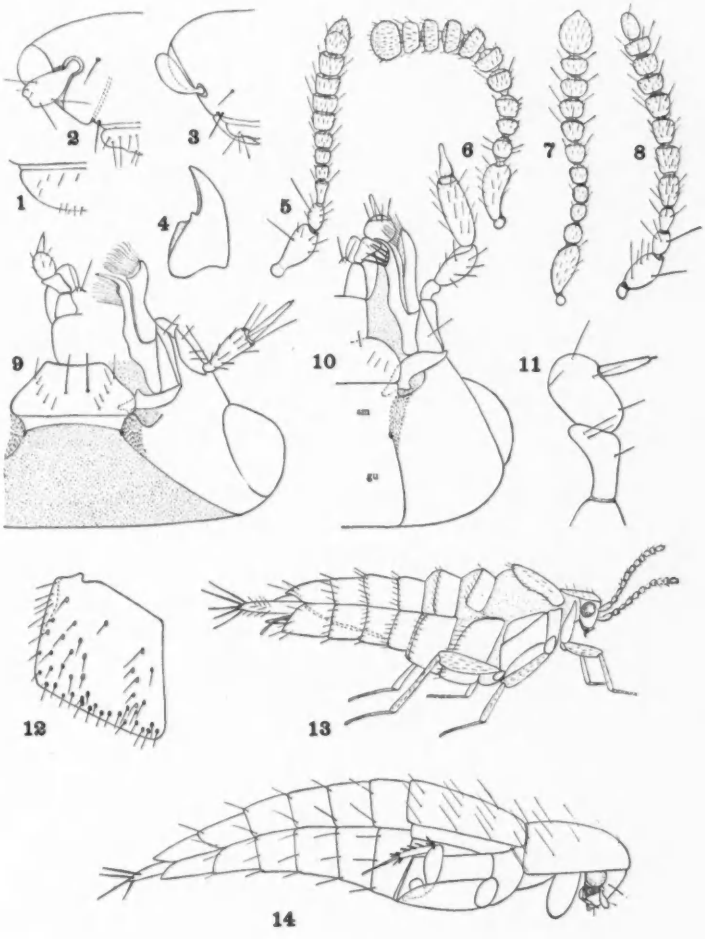
Fig. 15. *P. acanthoscelis*. Ventral aspect of mesothorax, metathorax and hind leg. Ventral plate removed from the right half of the metasternum to show the relationship of leg to thorax. 16. *P. acanthoscelis*. Dorsal aspect of metasternum, showing the furca and other endoskeletal elements as well as the muscles which insert on the head of the trochanter. 17. *P. acanthoscelis*. Enlarged dorsal view of metasternal cavity for the reception of the trochanter head, showing the two condyles to which the trochanter articulates, the coxa posteriorly, and the vertical apodeme between the coxa and metasternum. 18. *P. acanthoscelis*. Diagram of a vertical section of the metasternum to show the relationship of trochanter to the metasternum. 19. *X. hexagonalis*. Lateral view of mesothorax, metathorax and abdomen of male. Membranous areas stippled. 20. *X. hexagonalis*. Male. Ninth tergite, lateral plate, and anterior apodeme. 21. *X. hexagonalis*. Male. Eighth tergite. 22. *X. hexagonalis*. Male. Eighth sternite and outline of ninth sternite. 23. *X. hexagonalis*. Male. Ninth sternite. 24. *X. hexagonalis*. Lateral view of median lobe of aedeagus. 25. *X. hexagonalis*. Male. Flagellum of aedeagus. 26. *X. hexagonalis*. Lateral view of lateral lobe of aedeagus. 27. *T. depressus*. Female. Ventral view of terminal abdominal sclerites. 28. *P. acanthoscelis*. Female. Ventral view of terminal abdominal sclerites. 29. *T. depressus*. Dorsal view of male genitalia in relation to the abdomen, the segments of which are outlined.

Plate III

Fig. 30. *Termitohospes guianae*. Underside of head. 31. *Termitosocius microps*. Labium and maxilla. 32. *Termitocolonus ericiogaster*. Antenna. 33. *Termitohospes miricorniger*. Antenna. 34. *T. guianae*. Antenna. 35. *T. microps*. Antenna. 36. *Termitosodalis barticae*. Antenna. 37. *T. miricorniger*. Front view of head. 38. *T. microps*. Male. Ninth tergite and lateral plate. 39. *T. ericiogaster*. Dorsal aspect. 40. *Termitocomes wasmanni*. Maxillary palpus. 41. *T. wasmanni*. Galea and lacinia. 42. *Termitonannus setosus*. Maxilla. 43. *T. setosus*. Antenna. 44. *T. miricorniger*. Female. Terminal abdominal sclerites, dorsal aspect. 45. *T. miricorniger*. Female. Terminal abdominal sclerites, ventral aspect. 46. *T. microps*. Male. Lateral view of aedeagus. Lateral lobe stippled, the scleritized areas more heavily so.

ABBREVIATIONS USED ON FIGURES

ap—apodeme between coxa and metasternum.
cx—coxa.
dor—dorsal condyle for articulation of trochanter.
fu—furca of metasternum.
gu—gula.
ll—lateral lobe of aedeagus.
lp—lateral plate of ninth segment.
m—metasternum.
men—mentum.
md—muscle disk.
ml—median lobe of aedeagus.
mp—metasternal plate.
pm—prementum.
sm—submentum.
tc—cavity of metasternum for head of trochanter.
tr—trochanter.
ven—ventral condyle for articulation of trochanter.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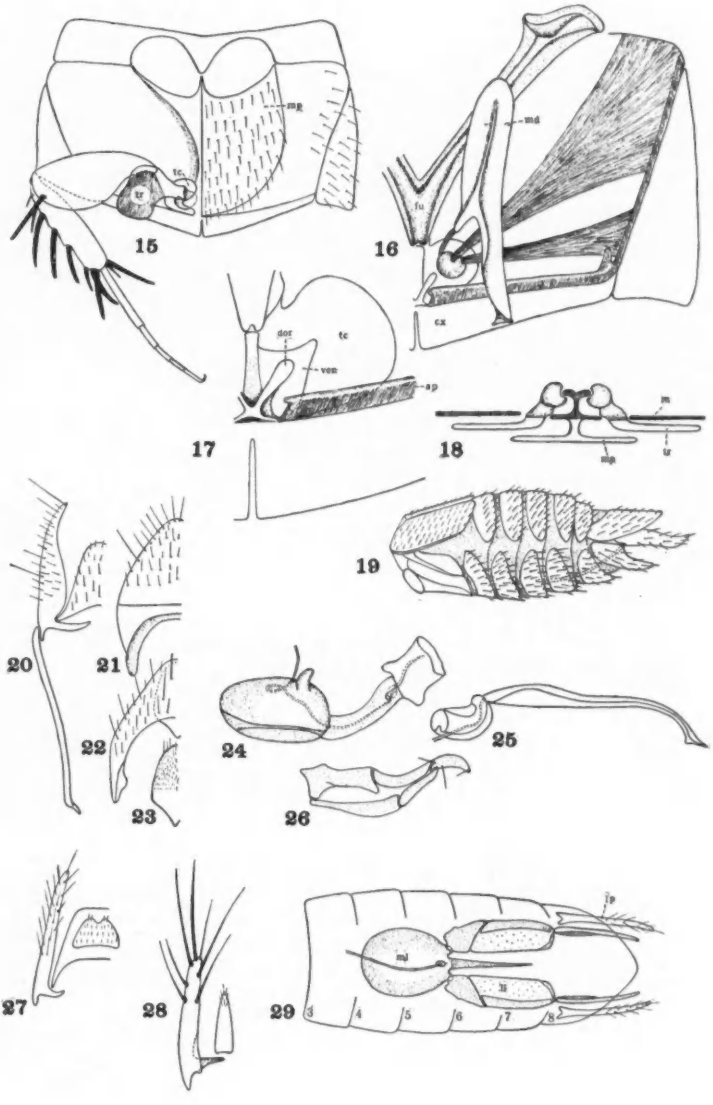
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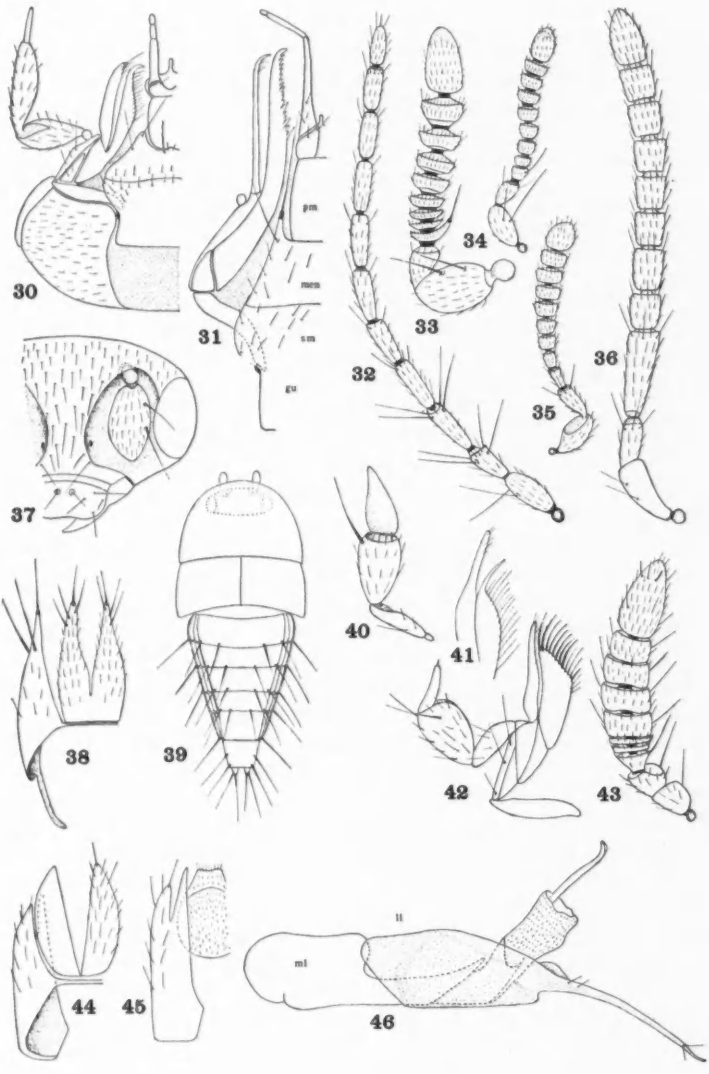
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THE GENUS HAPLOPOGON IN THE NEW WORLD, WITH THE DESCRIPTION OF ERINUS N. SP.

(Diptera: Asilidae)

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The genus *Haplopogon* Engel, which was proposed in 1930, was based upon a single species, *nudus* Engel. No subsequent mention of the genus has appeared in the literature. *H. nudus* is represented only by the type material, two males and two females, from Turkestan. Three additional species from the southwestern United States are here recognized as belonging to this genus, namely, *Holopogon lautus* Coquillett and *Holcocephala bullata* Bromley from Texas and one new species from Arizona.

No relationships of *Haplopogon* have been pointed out. This genus is closely allied to that group of Dasypogonine genera represented by *Holcocephala* Jaennicke and *Damalis* Fabricius. This relationship is indicated principally by the well developed prosternum which appears to extend to the pronotum in the form of a rather narrow bridge; by the simple lamellae of the female ovipositor; by the deep oral grooves, one on each side of the face; and by the open marginal and posterior cells. *Haplopogon* is more closely related to *Holcocephala*, because of the short, bare, antennal style which tapers to a point. However, the head of *Holcocephala* is much wider in proportion to its height, and the vertex is more deeply excavated. The bristles of the mystax which form an oral row in *Holcocephala* are evenly scattered over much of the face in *Haplopogon*, and the transverse facial groove, so characteristic of *Holcocephala*, is lacking in *Haplopogon*. *Holopogon* Loew, a genus to which one of the species has been referred, is quite remote in relationships.

The writer is grateful to Dr. S. W. Bromley, to Mr. H. J. Reinhard, and to Dr. C. E. Mickel for the use of material studied in connection with this paper.

Haplopogon Engel

1930. *Haplopogon Engel*, Flieg. Palaearkt. Reg., 24, Asilidae: 409. Fig.

Genotype.—*Halopogon nudus* Engel, by original designation.

The four species now included in *Haplopogon* all agree in having the body and legs blackish and the wings brown proximally. The genitalia of both sexes as well as other structural characteristics, habitus, and pattern of coloration of the three species from the southwestern United States appear to be very similar to the corresponding characters of the species from Turkestan.

The species found in the United States are known to occur only in the spring, all specimens noted being collected from early March to the first part of June.

TABLE OF NORTH AMERICAN SPECIES

1. Body brown pollinose; vestiture brownish; wings brownish, darker proximally (Texas) ..... **bullatus** (Bromley)
   Body cinereous pollinose; vestiture whitish; wings dark brown proximally, hyaline distally 2
2. Mesonotal vittae dark brown, strongly contrasting with pale pollen; brown of wings extending beyond discal cell (Texas) ..... **lautus** (Coquillett)
   Mesonotal brown pollen somewhat diffused, not contrasting with other pollen of mesonotum; brown of wings extending distad to cover only a portion of discal cell (Arizona) ..... **erinus,** new species

Haplopogon bullatus (Bromley), new combination

1934. *Holcocephala bullata* Bromley, Ann. Ent. Soc. Amer., 27: 89.
1938. *Holcocephala bullata* Pritchard, Jour. N. Y. Ent. Soc., 46: 19.

Type.—Holotype, male, in the collection of the Texas Agricultural Experiment Station.

Remarks.—Known only from the type material, Bexar Co., Texas, May 15–June 7, 1928, and Howe, Texas, June 13, 1933.

Haplopogon lautus (Coquillett), new combination

1904. *Holopogon lautus* Coquillett, Jour. N. Y. Ent. Soc., 12: 33.
1909. *Holopogon lautus* Back, Trans. Amer. Ent. Soc., 35: 314.
1934. *Holopogon lautus* Bromley, Ann. Ent. Soc. Amer., 27: 98.

Type.—Type, male, in the collection of the United States National Museum.

Remarks.—Described and previously known only by a single male, Brownsville, Texas, April. Material at hand is from Donna, Texas, March 3–April 7, 1935 (J. W. Monk).

Haplopogon erinus, new species

Entirely blackish, cinereous pollinose except for brownish on mesonotum and shining abdominal dorsum. Vestiture sparse, white. Wings

brown proximally, covering portion of discal cell, hyaline distally. Length, 4 to 5 mm.

Male.—Head one and one-half times as wide as high. Inner eye margins slightly divergent orally and above ocellar tubercle. Vertex but moderately excavated. Head cinereous pollinose. Mystax white, rather thin, consisting of long bristles on lower two-thirds of face; palpi well developed, with white bristles; ocellar tubercle with several white bristles; occiput very thinly clothed with white bristles and hairs. Antenna with proximal two segments subequal; third segment a little longer than proximal two segments combined, tapering somewhat; style as long as third antennal segment, acutely tapering, with a very short proximal division and with a whitish seta at distal end. Antenna brown, brown pollinose, with several white bristles under proximal two segments, with several white bristles above on third segment, the distal bristle being as long as style.

Thorax cinereous pollinose, the mesonotal vittae brownish, fused. Vestiture of thorax very sparse, white; mesonotal hairs short, sparse, recumbent; scutellum with several short, white hairs. Legs black, with white bristles and clothed with moderately dense, short, appressed white hairs. Claws yellowish on proximal third; pulvilli whitish. Wings fuliginose proximally, paler in anal area, hyaline beyond portion of discal cell. Posterior cells widely open, anal cell closed and petiolate. Halteres with stem brown, distal knob whitish.

Abdomen brownish black, shining dorsally, cinereous pollinose laterally and ventrally. Clothing of abdomen sparse, white, short, the recumbent dorsal setae especially sparse. Genitalia blackish; superior forceps elongate, broadened and attingent proximally, narrowed on distal portion, rather evenly rounded at tip; ventral plate well rounded, clothed with short, white hairs.

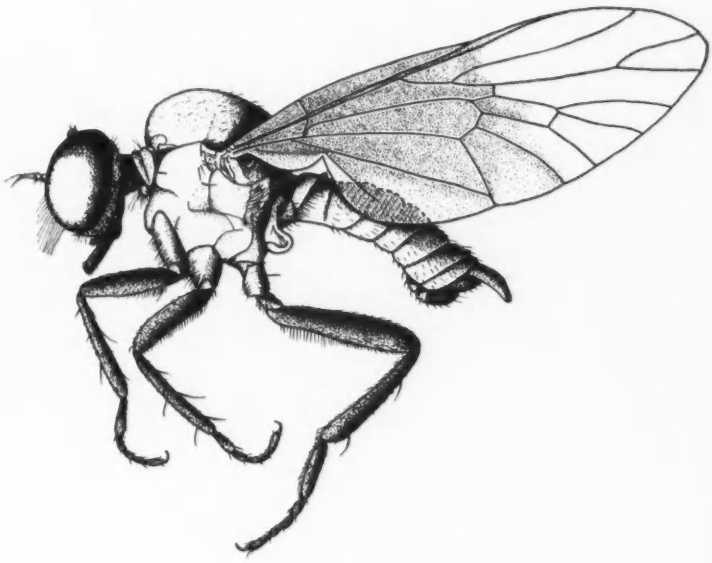
Female.—Similar, but brownish pollen of mesonotum not quite as extensive. Lamellae of ovipositor simple.

Holotype.—Male, Globe, Arizona, May 15, 1938 (F. H. Parker), in the collection of the University of Minnesota.

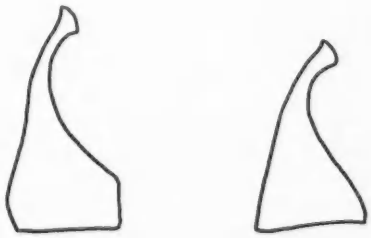
Allotype.—Female, Globe, Arizona, May 15, 1938 (F. H. Parker), in the collection of the University of Minnesota.

Paratypes.—Four males, eighteen females, Globe, Arizona, May 15, 1938 (F. H. Parker).

Remarks.—*Erinus* differs from *bullata* principally in having the body cinereous pollinose; the mesonotum lighter brownish pollinose; the vestiture whitish, that of the mesonotum and scutellum very sparse; the wings hyaline distally in contrast to the dark brown proximal portion; and the dorsal forceps of the male genitalia rather evenly rounded at the distal end. *Erinus* differs from *lautus* principally in being less robust; in having the brown portion of the wings less extensive, not extending distad to cover the discal cell; the brown or brownish



1. ERINUS



2. LAUTUS

3. BULLATUS

4. ERINUS

Fig. 1, lateral view of *Haplopogon erinus*, paratype, male. 2, dorsal view of left superior forceps of *H. lautus*, male, Donna, Texas, April 7, 1935. 3, dorsal view of left superior forceps of *H. bullatus*, paratype, male. 4, dorsal view of left superior forceps of *H. erinus*, paratype, male. 2, 3, and 4 drawn to same scale.

of the mesonotum rather diffuse, not contrasting sharply with the paler pollen; and in having the upper forceps of the male genitalia rather evenly rounded distally.

The type material was collected in a wheat field, ten to fifteen miles north of Globe. The chalcid, *Physcus varicornis* (Howard) [det. H. E. Milliron], was taken by the allotype female as prey. This chalcid is an aphelinid parasite of certain scale insects.

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CATALOGO SISTEMATICO Y ZOOGEOGRAPHICO DE LAS LEPIDOPTEROS MEXICANAS. Primera parto. Papilionaidae. CARLOS C. HOFFMAN. ANALES DEL INSTITUTO DE BIOLOGIA. Tomo XI, No. 2; pp. 639–739. 1940.

Dr. Hoffman of the Instituto de Biologia in Mexico City has done for lepidopterists a great work in compiling and publishing this catalogue. To my knowledge it is the first work of its kind done for an Hispanic-American country that in every way compares most favorably with the best catalogues published for the region north of Mexico in any European country. The typography is excellent. Pages 639 through 648 are devoted to a brief outline of the collection upon which the text is based, the authorities used for the various families and genera and a concise description of the zoo-geography of the Republic.

An invaluable paragraph for northern entomologists who are turning their attention to Mexico and the Mexican fauna is on page 64C which briefly indicates those areas that are in need of systematic collecting and study. The following pages through 723 list the species according to the most modern concepts of the systematic arrangement of the superfamily. For each species included is given the citation of its original description, a list of synonyms, the range of the species in Mexico and the forms that are found within the confines of that Republic. Seven hundred and eighty-two full species are noted. An index to every name mentioned, generic, specific, sub-specific and synonyms, arranged alphabetically occur in the last 16½ pages.

The data relative to the Mexican range of our more northern species make the article invaluable to the student of western lepidoptera and forcefully show that the custom of considering the fauna south of the Rio Grande some how set apart is entirely erroneous. The true break in the continuous flow of life forms for the temperate to the tropical fauna does not occur until the great transverse chain of volcanoes is met with in the southern highlands, although there is a northward extension of the tropical fauna and flora along the narrow coastal plain.—F. M. BROWN.

OBSERVATIONS ON CERTAIN LEPIDOPTEROUS AND HYMENOPTEROUS PARASITES OF POLISTES WASPS

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LEPIDOPTEROUS PARASITES

In an article entitled "Studies in the Ecology and Behavior of Polistes Wasps" (Bull. Brooklyn Ent. Soc. 33: 224–235, 1938, and 34: 36–44, 1939) I state that Lepidopterous parasites, *Dicymolomia pegasalis* emerged from a nest of *Polistes pallipes*. This statement brought an inquiry from a friend who wanted to know what the moth had fed upon in its larval stage. Did it, he asked, feed upon the wasp-larva itself, or the larval excrement plastered against the ceiling of the cell or was it perhaps upon the papery material of the nest? This moth belongs to the family Pyralididae, a few of whose members, like those of the Tineidae and a few other families of small moths, have acquired strange and unusual feeding habits. Many species have strayed so far from the generally accepted vegetarian habits of Lepidoptera as to be nothing short of astonishing. Mr. H. I. O'Byrne has called my attention to a few of the most outstanding examples. For example, there are two species belonging to the family Pyralididae, *Cryptoses choloepi*[1] and *Bradipodicola hahneli*[2] which inhabit the fur of living sloths, living continuously in it and causing its matted condition. Then there are two species of moths, *Tinea vastella*[3] and *T. orientalis*[4] that have been bred from the horns of cattle, where they feed upon the horny tissue. The larvae of *Zenodochium coccivorella*[5] and of *Euclemensia bassettella*[6] are internal parasites of the females of *Kermes* (Coccidae). The caterpillar of the latter species cuts a lid in the *Kermes*' gall so that it may easily emerge when it becomes adult. *Tinea fuscipunctella* (Forbes, *ibid.*, p. 126) breeds in the trash of pigeon nests and *Triohophaga tapetzella* (Forbes, *ibid.*,

[1]Dyar, Proc. Ent. Soc. Wash., 9: 142–144, 1907.
[2]Biol. Centralb., 36: 690, 1906.
[3]Busck, Smith. Miscel. Col., 56: 1–2, 1910.
[4]Walsingham, Proc. Ent. Soc. Lond., 1881, p. 238–241.
[5]Comstock, Introd. to Entom., 1925, p. 629.
[6]Forbes, Cornell Univ. Agric. Exp. Sta. Mem., 68, p. 357, 1923.

p. 131) is a clothes moth and general scavenger often breeding in owl pellets; while the larvae of *Monopis crocicapitella* (Forbes, *ibid.*, p. 132) breed in seeds of absinth and in refuse, and have also been taken in caves in association with bats. The larvae of *Valentinia glandulella* (Forbes, *ibid.*, p. 310) are scavengers on acorn weevils, while *V. quaintancella* (Forbes, *ibid.*, p. 327) are known to feed on mummy-apples, *i. e.*, apples entirely black and shriveled up from disease. *Pyroderous rileyi* (Forbes, *ibid.*, p. 327) feeds on mummy fruits, rotten cotton-balls and stored corn. We must not forget the notorious wax moths, *Galleria mellonella* and *Achroia grisella* which are scavengers in the comb and the wax of the honey-bee, and finally we have certain species such as *Aphomia sociella* and *Vitula edmandsii* whose larvae are found in the nests of bumble bees (Forbes, *ibid.*, p. 631).

The list of unusual feeding behaviors of these small moths could be lengthened considerably, but enough examples are given, I think, to show how diverse are the objects which they attack for food, and how far from the accepted vegetarian habits of the great order Lepidoptera have certain of its members strayed. Such change of habits and modification of instinct are of great evolutionary significance, and Dr. Brues in a paper on "Aberrant Feeding Behavior Among Insects and Its Bearing on the Development of Specialized Food Habits"[7] and Dr. Myers on "Facultative Blood-sucking in Phytophagous Hemiptera"[8] lay much stress on its importance.

With the knowledge of the diversity in the feeding behavior of the moths, its bearing on the theory of evolution, its importance in the lives and destinies of the social *Polistes* wasps—I gathered during the year of 1939 whatever data I could on the life-history of parasitic moths. In addition, I also gathered data on the Hymenopterous parasites of these wasps and I find it not out of keeping with the problems involved, to publish the data together with that on the Lepidoptera.

MOTHS KNOWN TO PREY UPON POLISTES WASPS

The moth, *Dicymolomia pegasalis* Wlk., already referred to, was not the first Lepidopteron that I had bred from Polistes nests. In Panama, I found a small moth, identified as one of

[7]Quarterly Review of Biol., 11: 305–319, 1936.
[8]Parasitology, 21: 472–479, 1929.

the Phycitinae, emerging from a paper nest of *Polistes canadensis* var. *panamaensis*, and also another moth identified as *Antispila* sp. [A. Busck], emerging from certain webby cells of the same species (Jungle Bees and Wasps of Barro Colorado Island p. 112, 1933).

Another Microlepidopteron, *Epithectis sphecophila* Meyr., (Gelechiidae), was bred from the nest of *Polistes canadensis* in Trinidad by Meyerick (Exotic Microlepidoptera 4: (20) 624, 1936; published by the author).

Two species of Microlepidoptera have been bred from Polistes wasps from Puerto Rico, and are described by Forbes (Psyche, 40: 89–93, 1933); *Taeniodictys sericella* were bred from nests of *Polistes crinitus* and *Antipolistes anthracella* from nests of *P. crinitus* and *P. cubensis*.

In 1921 I found many *Polistes annularis* nests infested with the moth *Tinea fuscipunctella* (Canad. Entom. June, 1930, p. 120), but I have never again found it in any of the Polistes nests. This moth is mentioned in one of the foregoing pages, on the authority of Forbes, as breeding in trash in pigeons' nests and other refuse, but whether in Polistes' nests it feeds on the refuse, on the paper walls, or on the wasp larvae, I do not know.

RECORDS OF MOTHS WHOSE HABITS RESEMBLE THOSE OF D. PEGASALIS WLK.

Before giving details on the biology of our Missouri *D. pegasalis*, I would like to state what is known on three other species whose habits are similar to those of *D. pegasalis*, and whose taxonomic relationship is very close; one species in particular belonging to the genus *Dicymolomia*. The three examples are taken from the extremely valuable paper by Dr. C. T. Brues already referred to. He cites Fletcher[9] who finds that in one Australian species of *Stathmopoda* the food consists of eggs of spiders, and he also cites Gahan[10] and McCreary[11] who found the larvae of the North American species *Dicymolomia julianalis* feeding on the eggs of the bagworm *Thyridopteryx*, each caterpillar invading the case of the female bagworm which is filled with eggs. In the same family to which *Dicymolomia* belongs, the Pyralididae, he further states, there is an Indian member,

[9]Mem. Dept. Agric. India; Ent. Ser. 6, nos. 1 to 9, 1920.

[10]Journ. Econ. Entom., 2: 236–237, 1909.

[11]Journ. Econ. Entom., 23: 883, 1930.

Phycita dentilinella whose caterpillars feed on pupae of a Eucleid moth, as well as those of a wild silkworm *Cricula trifenestrata*.[12]

These citations bring us close to our own species, both in the matter of behavior and in taxonomic relationships, but before stating the details of our study of *D. pegasalis*, however, I should like to say a word about my calling this moth parasitic. In the foregoing citations, it will be remembered that various authors refer to the caterpillars as feeding upon a certain insect species, implying, if not actually saying so, that the species is predatory. That is as it should be in the case where the caterpillar crawls into the cocoon and feeds on the bagworm eggs; but if a mother moth deposits an egg in the cell of a wasp-larva and the ensuing caterpillar slowly feeds upon it, spins its cocoon and pupates within the wasp's cell, as the moths I am about to describe have done, I think I am justified in calling this behavior parasitic—in fact I know of no other name by which to call it. In this definition, Dr. Wheeler bears me out for he says (Foibles of Insects and Men, 1928, p. 51) "Parasites put other organisms in the position of 'hosts' by living directly on their tissues in such a manner as not to cause their immediate death. The parasite thus draws indirectly on the food supply of another organism by permitting or compelling it to do the hard work of procuring the food and of converting it into much more accessible and much more easily assimilable compounds. The parasite may be said, therefore, to use its host as an instrument not only for procuring, but for predigesting its food."

THE LIFE HISTORY OF DICYMOLOMIA PEGASALIS [CARL HEINRICH][13]

The observations recorded below answer the question in the opening paragraph—upon what does the caterpillar of this species feed? I have found that it does not feed upon the paper walls of the wasp's nest as was at first suspected, and neither does it feed upon the larval excrement that is plastered on its walls. It is actually parasitic on the larva itself, and I have bred it from nests of *Polistes pallipes*, *P. annularis*, and *P. variatus* taken in Missouri within 100 miles of St. Louis. The

[12]Ramakrishna Ayyar, Journ. Bombay Nat. Hist. Soc., 33: 668–675, 1929.

[13]The names of the experts who identified the material appear in brackets throughout the paper.

fourth species found in Missouri, *P. rubiginosis*, had no infestation in the few nests studied in 1939, but some years ago moths that looked much like *D. pegasalis* emerged from a nest of *P. rubiginosis;* these, however, were not submitted to experts for identification, and the species is in question. There is, however, no reason why *P. rubiginosis* should not likewise be subjected to their attacks unless it be that, unlike other species of Polistes, their nests in hollow trees and in between dark walls are not easily accessible to the parasites.

For the purpose of this and other studies on Polistes behavior, some 200 nests with living larvae were brought into the laboratory. Collecting trips were made from time to time during the summer of 1939, and as the season advanced, as one would expect, the size of the nests were progressively larger. It is of interest to note that during the early part of the summer when the nests were small, no moth infestation occurred; some of the nests taken in the middle of summer, however, were infested and the moths became adult from the middle of July to the middle of August. The Polistes nests that were parasitized were collected in Missouri at Kirkwood, Ranken, Pacific, Allenton, Crocker, Robertsville, Rosetti and Arcadia. About 20 of the 200 nests, or about 10% were parasitized by these moths. In some cases only one cell was infested, in others as many as 50% were infested (one 80 cell nest of *P. annularis* in particular had 41 parasitized cells). The nests most affected were the outdoor nests of *P. annularis*, while *P. pallipes*, with smaller nests built under the shelter of man-made structures, had fewer nests as well as fewer cells in the nests parasitized.

In our local Polistes wasps, the hibernating queens commence nest building at the end of April or early May, and the first of the workers are on the nest at the end of May or early June, but it is not until the last days of June and the first of July that the first of the moths emerge. This would roughly indicate that the period from the hatching of the egg to the emergence of the wasp is about 30 days. Since the moths emerged at the end of July and in early August, one would suspect that this is the second generation which in turn will oviposit and give rise to a third overwintering generation. Since we find quiescent overwintering larvae in the cocoons it is reasonably certain that there are three generations. The dates of the emergence in the table below will show how I arrive at what I call the second generation.

Species	*Location*	*No. of Moths to Emerge*	*Date of Emergence of Moths*
Variatus	Allenton	2	July 12
Variatus	Allenton	12	July 25 to 27
Pallipes	Ranken	6	July 11 to 12
Pallipes	Robertsville	3	June 29
Variatus	Robertsville	22	June 28 to July 4
Pallipes	Arcadia	10	7 on July 24–26; 3 on Aug. 4
Variatus	Allenton	20	July 26 to Aug. 1
Pallipes	Allenton	5	July 13 to 16
Variatus	Allenton	8	Aug. 1 to 3
Pallipes	Ranken	5	Aug. 8
Annularis	Rosetti	32	Aug. 6 to 12
Variatus	Rosetti	35	Aug. 6 to 10
Variatus	Crocker	9	Aug. 10 to 12
Pallipes	Allenton	1	Aug. 23

The table shows that the number of moths emerging from nests are irregular—one, two or three each from some nests to as high as 32 to 35 from other nests; in addition there is the nest mentioned on another page where 50% of the 80 odd cells were parasitized.

It seems to me that the parasites which became adult in the summer have an easier time to find hosts than those of the spring generation. The former have only to mate and oviposit on the wasp larvae in the nest from which they emerged, while those of the spring generation, having emerged from empty nests, must go elsewhere in search of hosts.

One host-larva usually nourishes one parasite but if it belongs to a large species of wasp, such as *P. annularis*, one larva may support two and sometimes three parasites. Each caterpillar, however, regardless of how many may occupy one wasp cell and feed upon one host, spins its cocoon independently. The cocoon is very white and silky, somewhat parchment-like and is composed of from 4 to 7 layers with small air spaces irregularly between them. The bag is cylindrical, fits tightly into the wasp cell and has a slit across the top, which opens when pressed with the fingers. I was at first uncertain if the slits had been made by the emerging adults struggling to gain freedom or if they were left open by the larvae in the spinning process. Later, however, when some cocoons were found containing living larvae, it was apparent that the opening at the top of the bag was the result of the spinning work of the larvae.

If the host is small or of medium size, it is always completely eaten by one caterpillar. If it is large and supports only one caterpillar, sometimes as much as one-fourth of the bulk remains

uneaten. This is always pressed against the wall or roof of the cell where it does not interfere with the spinning of the cocoon.

Just how the eggs are deposited on the host I do not know, but on several occasions when many moths were flying about in a cage containing a Polistes nest, I found many bright yellow eggs scattered among the cells. These, I presume, are eggs of the moth and the fact that none of them hatched leads me to believe they were infertile.

It would be of interest to know how the mother oviposits on the host when the nest is covered with watchful wasps. The egg-laying in the spring might be carried on when the lone queen is occasionally away from the nest. The second generation might find egg-laying easier since they were reared in a nest with living wasps; they may have acquired a nest-odor which the wasps would tolerate; but since the majority of moths are nocturnal it appears probable that they enter the nests and oviposit when the wasps are asleep. I have often collected Polistes nests at night and have seen, at various times, wood roaches, *Parcoblatta pennsylvanica*, feeding on larvae and honey while the wasps were asleep. So likewise it may be possible for the moths to steal into the nests at night and deposit their eggs.

As already stated, the moths pass the winter as quiescent larvae in their silken cocoons in the Polistes nests. Upon opening (January, 1940) several cells in a nest of *P. annularis* collected in the woods in the previous November, I have found many such larvae. It will be interesting to discover at what date the moths emerge in the spring, and how they spend their early life until hosts are large enough to be parasitized.

There is a condition which at first is apt to puzzle the observer; in looking at an inverted parasitized nest one notices the cocoons of *D. pegasalis* a little below the rim of the cell and sometimes in addition, one finds that a thin web is spread over the opening at the rim. This web is not made by the caterpillar as I once thought, but it is the feeble attempt of the parasitized larva to spin the lid to its cell. The same feeble attempts at spinning can be seen in unhealthy or starved Polistes larvae that have been kept in the laboratory. Normally this cover is made by the wasp larvae just before pupating and is very strong and substantial.

THE LIFE HISTORY OF THE MOTH, CHALCOELA IPHITALIS WLK.
[CARL HEINRICH]

The notes which were obtained on this species do not cover its entire life history, but sufficient data have been gathered to indicate that its behavior, in a marked degree, resembles that of its near relative, *D. pegasalis*. Moths of *C. iphitalis* were bred from the paper nests of Polistes wasps taken in Texas and Mexico. The nests from Mexico were collected at Tamazunchale, S. L. P., in February 1939, belonged to the species *Polistes instabilis*, and also from an unknown species which probably, judging from the shape of the nest, was that of *P. carnifex* or *P. major*. The nests from Texas were collected at Artesian Wells, about 50 miles from the Mexican border, and were also either *Polistes carnifex* or *P. major*. The nests were old and were without wasp larvae or pupae, but there were living moth larvae within the cells snugly encased in their cocoons. The moths emerged at Kirkwood in the spring of the same year. In a nest of *P. instabilis* with 175 cells, thirty-three had parasitic moths, twenty-eight of which emerged between March 20 and 24, two on March 28, and three at a much later date, May 16. In another nest of the same species fourteen moths emerged as follows: Eight from March 20 to 25, four from March 26 to 28, one on April 20, and one on April 28. In a third nest, six moths emerged from March 20 to 25. There does not seem to be any regularity in the time of hatching, but one may say that they emerged intermittently over a period of about sixty days—March 20 to May 16. In the nests from Texas the moths became adult and left the cells much later in the spring—from June 10 to June 12.

The caterpillars of *C. iphitalis*, like those of *D. pegasalis* feed on the larvae of the wasps. This was revealed to me when I dissected the nests and found portions of uneaten host larvae pressed between the cocoon and the cell wall, and also when I found, upon careful examination, that excrement and nest material remained untouched in the parasitized cells. The moth larvae spin heavy silken cocoons which are indistinguishable from those of *D. pegasalis*. The cocoon is just as stout, is made up of the same number of layers of silk, has air-pockets between the layers, and also has an opening at the top. Like *D. pegasalis* it completely fills the wasp cell.

Polistes instabilis is what I would call a medium size wasp, and in the parasitized nests I found but one moth in each host cell, but in the nests of the larger species, *P. major* or *P. carnifex*, I found that two, three and even four parasites had been supported by one host larva. Like *D. pegasalis* these caterpillars spin cocoons independently, and even though three or four lived in one cell on one host, no community spinning was indulged in.

In opening the nests containing the cocoons of *C. iphitalis*, I found that all of them had come to maturity—there was no mortality, every cocoon having given forth a finished product.[14]

HYMENOPTEROUS PARASITES

I have placed on record from time to time the hymenopterous parasites bred from Polistes nests. These are summarized below:

Apanteles carpatus Say and *Tetrastichus* sp. Both species emerged from nests of *P. annularis* along with the moth *Tinea fuscipunctella* (Canad. Entom. June 1930, p. 120). I find in an article by Washburn, (Hymen. of Minn. p. 185, 1918) that certain members of the genus *Tetrastichus* are parasitic on the Hessian fly, and that *T. esurus* is parasitic on the cotton worm and also that many species have been bred from galls. With this knowledge of the hosts of other species of *Tetrastichus*, the probability is that our species is parasitic on the moth, *Tinea fuscipunctella*, rather than on the larvae of the wasp. *Apanteles carpatus* was also undoubtedly parasitic on *Tinea fuscipunctella*, which may have fed on paper or excrement or may have been parasitic on the wasp larvae. In an account of *A. carpatus* in "Insects of New York" (Cornell Agric. Exp. Stat. Memoir 101, p. 906, 1928) I find that it is a widely distributed parasite of various clothes moths, *Tinea pellionella*, *Trichophaga tapetzella* and *Tineola biselliella* and also in a large list of species belonging to the genus *Apanteles* given in Hymenoptera of Connecticut,

[14]Since writing the above account, I have made a second trip to Mexico and have procured additional information on the life-history of *C. iphitalis*. During July, 1940, nests of social wasps which were infested by this moth were taken at Xilitla, S. L. P., Tamazunchale, S. L. P., Taxco, Gro., Cordoba, V. C., Victoria, Tamps., Villa Jaurez, Tamps, and at Rio Grande City, Texas. The species of wasps parasitized by these moths were: *Mischocyttarus basimacula*, *Mischocyttarus* sp., *Polistes instabilis*, *P. major*, and in Texas *P. exclamans*. Hundreds of moths emerged between July 14 and 30 while we were en route, from the live wasps' nests we had collected and placed separately in cellophane bags. Since, as stated above, the overwintering moths emerged in March and April, this July exodus establishes conclusively at least two generations a year in *C. iphitalis*.

1916, I find all species are parasitic on Lepidoptera and *A. carpatus* in particular has been bred from the moth, *Tinea pellionella*. This, then, would point to *A. carpatus* as a parasite of *Tinea fuscipunctella* rather than as a parasite of *Polistes annularis*.

Christelia arvalis Cress. Several cells in a nest of *Polistes rubiginosis* taken at Wickes, Missouri, were parasitized by this insect. The parasites preyed upon the wasps in both the larval and pupal stages, and emerged as adults in early September, 1919. One immature wasp being host to six parasites (Rau, Psyche 38: 144, 1931).

Polistiphaga fulva Cress. In the pages that follow I shall record new details on the life-history of this parasite. Before doing so I wish to review what has already been recorded on this species: thirty parasites emerged on September 28 to 30 from a nest of *Polistes variatus* taken at Columbia, Illinois (Rau, Bull. Brooklyn Ent. Soc. 26: 114, 1931). There is a record of another species, *Polistiphaga arvalis* that is also parasitic on *Polistes* sp. (Cornell Agric. Exp. State. Memoir 101, p. 993, 1926).

RECORDS FOR 1939

Polistiphaga fulva Cress. [R. A. Cushman]. Since recording the parasitization of *P. variatus* by *Polistiphaga fulva*, as mentioned in the last paragraph, I have had the parasites emerge from nests of *P. variatus* from several Missouri localities; I have also bred them from the three other species found in Missouri, *P. pallipes*, *P. annularis*, and *P. rubiginosis*. The Missouri localities from which infested nests were collected are Kirkwood, Wentzville, Allenton, Crocker and Rosetti.

Polistiphaga fulva is actually parasitic on the wasp larvae. Since it belongs to the Ichneumonidae, one would hardly expect anything else. Just how and when the egg is deposited, I do not know, but I have on several occasions seen a female *P. fulva* loiter about a Polistes nest for hours at a time, evidently awaiting an opportunity to enter the nest. I have bred from one to eight parasites from a single wasp cell, showing of course, that one host harbored that many parasites. The hosts are parasitized at no particular age or size, and the number of eggs deposited may be influenced by the size of the host. Sometimes parasitization takes place after the larva has spun the lid to its

cell and I have also seen cases where the larvae had transformed into pupae before infestation occurred. The parasites, after having finished feeding, spin cocoons for themselves, becoming adult late in the summer season, and then gain their freedom by biting round holes in the top of the cocoons.

A record was kept of the time of emergence of *P. fulva;* sixty individuals emerged from four nests from Crocker, Missouri, (one nest of *rubiginosis*, two of *variatus* and one of *pallipes*) from August 10 to 21, 1939, and from a nest brought from Wentzville, Missouri, six *P. fulva* emerged somewhat earlier, July 12, 1939, and the very latest date in the season is the record of 30 parasites which emerged from a *P. variatus* nest, September 28 to 30, (Bull. Brook. Ent. Soc. 26: 111–118, 1931).

Brachymeria new species [A. D. Gahan]. This species (my Nos. 1431 and 1436) is new to science and a description by Mr. A. B. Gahan is in course of publication. Seven parasites emerged at Kirkwood, Missouri, May 7 to 14, 1939, from two paper nests of *Polistes instabilis* collected in February at Tranzunchale, S. L. P., Mexico. From one of these nests I also bred several moths, *Chalcoela iphitalis* recorded earlier in this paper, but the hymenopterous parasites gave every evidence of being parasitic on the wasps and not on the moths.

I also recorded[15] another species of *Bachymeria* from Mexico, *B. mexicana* as being parasitic on the mud wasp, *Trypoxylon mexicanum.*

Dibrachys cavus Walk. [A. B. Gahan]. Dead insects of this hyper-parasite were found in three cocoons of the moth, *D. pegasalis.* The cocoons were in a nest of *Polistes variatus* taken at Diecke, Missouri, September 25, 1938. I find in Insects of New York (1926 p. 980) a record for another species, *D. boucheanus*, having been bred from a cocoon of *Apanteles clisiocampae*, and in Hymenoptera of Connecticut (p. 475) there is a long list of Lepidoptera upon which *D. boucheanus* is parasitic.

Melittobia sp. This small chalcid-wasp plays havoc with live Polistes larvae brought into the laboratory, although after many years of observation, I have never obtained evidence that they attack colonies in their natural habitats. The source of infestation in my laboratory is the collection of nests, almost always on hand, of *Sceliphron caementarium* and *Trypoxylon politum.*

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[15]Ann. Ent. Soc. Amer., March, 1940.

SUMMARY

To summarize the data given in this paper we find that:

1. The moth *Dicymolomia pegasalis* is parasitic on the larvae of *Polistes pallipes*, *P. variatus*, *P. annularis* and *P. rubigenosis*.

2. *Tinea fuscipunctella* hatches from the nest of *Polistes annularis* but it is not known if the caterpillars feed on the larvae of the wasp or on the debris or on paper walls of the nest.

3. The moth, *Chalcoela iphitalis* is parasitic on the Mexican *Polistes instabilis* and also on a larger species which may be *P. carnifex* or *P. major*. (See also footnote 14.)

4. The larvae of the moth, *Tinea fuscipunctella* is probably hyper-parasitized by *Apanteles carpatus* and *Tetrastichus* sp.

5. The parasitic hymenopteron, *Polistiphaga fulva* is directly parasitic on the larvae of *Polistes annularis*, *P. variatus*, *P. pallipes* and *P. rubiginosis*.[16]

6. *Brachymeria* [new species] emerged from nests of *Polistes instabilis* from Mexico, where it is directly parasitic on the wasp larvae.

7. *Dibrachys cavus* is hyper-parasitic on the moth *D. pegasalis* which in turn, is parasitic on Polistes larvae.

8. *Melittobia* sp. is a dreadful pest to Polistes larvae in the laboratory where the source of infestation is other Hymenopterous larvae brought in for study, but in their natural habitat Polistes wasps seem not to be troubled by them.

[16]An interesting paper by A. T. Gaul, on the "Biology of *Polistiphaga arvalis* Cress." (Canad. Entom., Dec., 1940) has appeared too late for a discussion of it to be included here.

PRUNING TREES AND SHRUBS, by EPHRAIM PORTER FELT. 237 pages, 91 figs. 5.5. x 8 inches. 1940. Published by ORANGE JUDD PUBLISHING Co., 15 East 26th St., New York City. Price, $2.00.

While not entomology, this is a volume written by a leader in the science; further, proper or special pruning is used by entomologists against certain insect pests. The subject matter is handled as follows: Chapter I. Nature a Guide; II. Growing Sturdy Trees; III. Possibilities of Pruning; IV. Guidance Pruning; V. When to Prune; VI. Tree Repair; VII. Line Clearance; VIII. Safety in Tree Work; IX. Hedges; X. Fruit Trees; XI. Small Fruits; XII. Nut Trees.

We quote from the author's Introduction: "This book is not intended to be exhaustive. Its aim is to present in concise form and non-technical language the more important matters in relation to pruning of woody plants. It is intended for the individual who may have a few trees or shrubs rather than for the extensive fruit grower."

The book is well printed on thick strong paper and is in a strong, easily opened binding. The illustrations are photographs of actual examples under discussion.

—C. H. K.

THE LARVA OF LIMONIUS CONSIMILIS WALK.

(Coleoptera, Elateridae)[1]

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The wireworm *Limonius consimilis* Walker is closely related to *Limonius bructeri* (Panz.) of Europe, which Eschscholtz made the genotype of *Limonius* in 1829 and Kiesenwetter of *Pheletes* in 1858 and is now placed in synonymy under *L. aeneoniger* (Degeer) by Schenkling (1927). These species apparently stand alone in their respective faunal zones and together represent a group which is distinct from the other species usually included within the larger concept of the genus *Limonius*.

The larva of *Limonius consimilis* Walker has not been mentioned in literature[2] nor was it known to the author prior to the spring of 1938. These native larvae were found in moss on a sheltered rock in a basaltic slide formation on the bank of the Snake River near Asotin, Wash., and four adults were obtained by rearing. More recently numerous larvae and adults were secured from the same slide. The representative material of the European species was secured for study from the United States National Museum through the kindness of Dr. A. G. Böving. The larva of *Limonius aeneoniger* (Degeer) has been illustrated and briefly described by Schiödte (1870) as *Elater* (*Pheletes*) *bructeri* F. and the habitat is given as under moss. Henriksen (1911) treated it under the name *Pheletes bructeri* Panz. and as the example for the genus in a table which forms a part of the English summary of his survey of the larvae of the Danish elaterids.

GENERAL DESCRIPTION[3]

LENGTH 12.5 mm., breadth 1.3 mm. (nearly ten times as long as wide); dorsoventral thickness 1.1 mm.

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[1]This work was done under the direction of M. C. Lane as a part of the Pacific Northwest wireworm investigations of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

[2]This species is not mentioned by J. S. Wade in his mimeographed paper entitled "A Contribution to a Bibliography of the Described Immature Stages of North American Coleoptera" (U. S. Bur. Ent. and Plant Quar., E-358, 114 pp., 1935).

[3]The descriptions are written as a basis for further taxonomic work within the genus and have the larvae of other species of *Limonius* in mind rather than coleopterous larvae in general or the larvae of other elaterid genera.

BODY similar to those of other *Limonius* larvae studied, somewhat dorsoventrally depressed, subparallel, gradually narrowed toward each end by about one-fifth. Moderately sclerotized, orange yellow in color, except tergal plates, upper surface of head, urogomphi, and mandibles, which are increasingly more heavily sclerotized and darker.

HEAD narrowed in front, rounded anteriorly owing to the arched mandibles; broadly convex posteriorly, progressively flattened anteriorly, concave between antennae. Nasal projection consisting of three subequal, parallel teeth. Ocelli present. Mandibles four-toothed. Sclerotized plate of postlabium broad posteriorly.

TERGA of thoracic and abdominal segments uniform except for darker color of the prothorax; surface coarsely and densely punctate; anterolateral grooves not prominent, short. Three pairs of setae-bearing depressions near posterior margins, the two setae in each depression usually unequal in length.

NINTH ABDOMINAL SEGMENT uniformly narrowing to shortly before vertical branches of urogomphi, rounded posteriorly. Tergal disk nearly round, margined laterally, swollen medially, with small depression near center, surface very irregular. Vertical branches of urogomphi small, setae-bearing, blunt cones on margin of disk distinctly laterad of "keyhole," separated by three times diameter of "keyhole." Horizontal branches extending posteromedially and nearly enclosing "keyhole." Inner margins heavily, darkly sclerotized.

TENTH ABDOMINAL SEGMENT unarmed except for setae, anal lobes protrusive, anus a longitudinal slit.

DETAILED DESCRIPTION

HEAD CAPSULE (figs. 1, 2, 3) narrowed and dorsoventrally reduced anteriorly, not extremely wedge-shaped. Length from base to insertion of mandibles only two-thirds width of head. Dorsal surface with numerous round pits which vary in size and appear lighter colored than surface of integument, densest in mediolateral areas. Six pairs of long setae from similar but larger pits on dorsal surface. These are situated, one on each side, (*a*) on lateral wing of nasale, (*b*) on wing of frontoclypeal plate shortly anterior to frontal suture, (*c*) behind ocellus, (*d*) below and in front of ocellus (*OC*), both *c* and *d* posterior to base of antenna, (*e*) a seta located medially near lateral margin (dorsal aspect), and (*f*) one, more medial, forming an equilateral triangle with postocular and lateral setae. An irregular row of small setae posterior to *f* marking course of dorsolateral groove or suture (*DLS*) to postoccipital suture (*PCS*). On ventral surface of head, on each side, a longitudinal sulcus—hypostomal suture (*HS*)—extending from near ventral, mandibular condyle medioposteriorly, parallel to lateral margins of stipes, toward paragenal area. Each sulcus bearing two long setae (*g* and *h*), separated by over half length of sulcus, as well as smaller setae. A third long ventral seta (*i*) mediolaterally near lateral seta (*e*) of dorsal surface.

Frontoclypeal plate (*FN*) (fig. 1) distinctly outlined on dorsal surface by frontal sutures (*FS*) which arise from the postoccipital suture (*PCS*), separated at their bases by a distance half greatest width of

posterior part of plate and equal to that of constriction between anterior and posterior parts of plate. Anterior to constriction each suture extending laterally and finally curving anteriorly between base of antenna and mandible. Greatest width in posterior portion of plate near the rather long constriction.

Nasal projection (*NP*, fig. 1) consisting of three uniform, equal, tapering teeth which appear to arise individually from level of bottom of nasal depressions (*ND*).

Medial margins of *lateral wings of nasale* (*NLW*, fig. 1)—paranasal lobes—extending anteriorly from nasal depressions twice length of nasal projections before bending laterally over mandibles.

Dorsal mandibular condyle strong, darker colored.

Ocellus (*OC*, fig. 3) a distinct black area lateroposterior to base of antenna, with long seta (*c*) posterior to it, somewhat smaller one (*d*) ventrad. Distinct in color and outline, in slight depression, under epicuticula at least, and extending inward as a darkened body, hence not showing in cast skins.

ANTENNA (*ANT*, figs. 1, 3) 3-segmented, subequal in size to maxillary palpus (*MPS*, fig. 2), basal segment slightly swollen distally, longer than wide; intermediate segment about half as wide as first and nearly as long as wide; distal segment very slender, about one-third as wide as intermediate one, approximately three times as long as wide. Slender membranous cone distally on intermediate segment, closely associated with distal segment, about two-thirds its length. Setae inconspicuous, but single sensory papillae scattered on first segment, more densely on second, near distal ends. Tip of third segment with three or more distinct and larger papillae.

MANDIBLE (*MAN*, figs. 1, 6) heavy, but slightly sickle-shaped, more uniformly curved externally than commonly found in this genus. Cutting edge modified from normal form with distal lobe (*MDL*) and proximal lobe (*MPL*), or retinaculum, by development of two secondary teeth on distal lobe. Tip of primary distal lobe slender, long, a secondary lobe attached on each side. Secondary lobes shorter than primary lobe, only slightly set off from it, and, though slightly posterior to it, mainly dorsal and ventral to it, respectively. They form with the primary lobe the half-round of a cup. All lobes nearly transverse, conical in distal portions, pointed. An anterodorsally-directed seta near anterior end of lateral surface of each mandible. A similar seta approximately midway from first one to dorsal articulation of mandible. Both setae on dorsal surface within lateral depression. Mandibular brush (*MB*, fig. 6), or penicillus, present.

VENTRAL MOUTH PARTS (*LJ*, fig. 3) forming plate moving as a unit, cardines acting as hinges. When relaxed this plate, excluding the appendages, extends as far anteriorly as do the mandibles.

Cardines (*C*, fig. 2) moderate, rhomboidal in form, inner margins approximate, distal margins articulating with adjacent ends of stipites. Cardinal suture (*CSU*) extending from middle of base to proximal tip of each sclerite darker than otherwise uniformly yellowish plate. Proximal tips of cardines articulating with sclerites at proximal end of hypostomal basin.

Stipites (*S*, fig. 2) large, elongate, parallel, sides very slightly divergent distally, separated by postmentum; heavily sclerotized, yellow to a diagonally transverse line shortly posterior to appendages, distally membranous and white; a point of darker color at base opposite distal end of cardinal suture; lateral margins shading darker. Two long setae; two, three, or even four smaller ones, near distal end of lateral margin.

Lacinia (*LAC*, fig. 2) elongate, hidden by dense hair growth, especially dense on surface toward prementum.

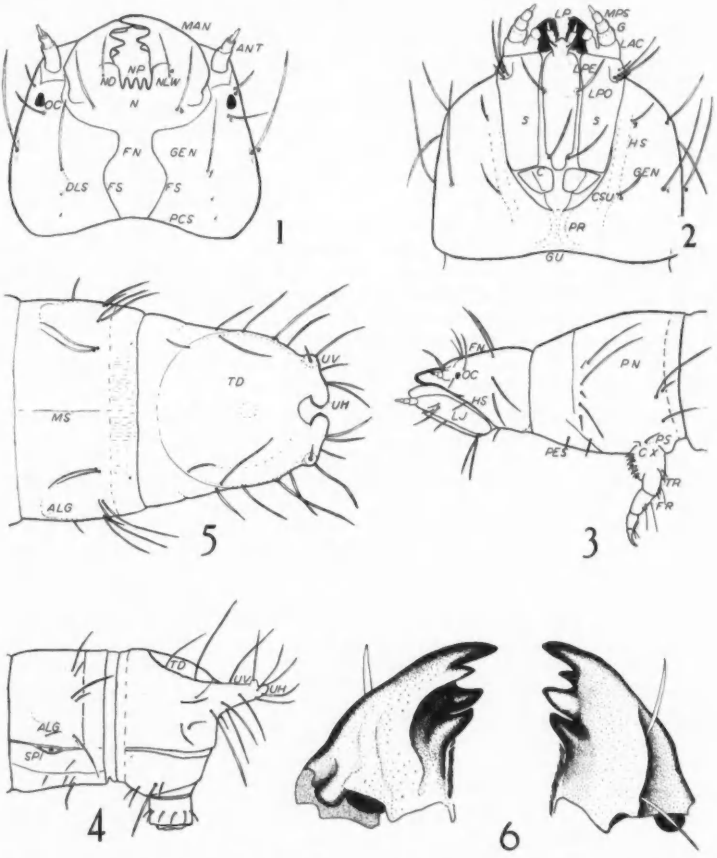

Fig. 1. *Limonius consimilis* larva. Head capsule—dorsal. Fig. 2. Larva. Head capsule—ventral. Fig. 3. Larva. Head and prothorax—lateral. Fig. 4. Larva. Last abdominal segments—lateral. Fig. 5. Larva. Last abdominal segments—dorsal. Fig. 6. Larva. Right mandible, ventral and dorsal.

Galea (*G*, fig. 2) 2-segmented, about equal to lacinia, half as long as maxillary palpus. Proximal segment short, narrowly sclerotized; distal one slightly narrower and longer, more widely sclerotized. Anteromedially-directed tip with sensory papillae and ring of long, stiff setae.

Maxillary palpus (*MPS*, fig. 2) 4-segmented, bending anteromedially. Segments short, cylindrical, nearly equal in length except for shorter third; gradually reduced in diameter, distal segment about one-third as wide as first; rather darkly sclerotized, joints white, membranous. Setae on first and third, sensory pits on all four near distal margin of sclerotized band. Tip of distal segment covered with papillae.

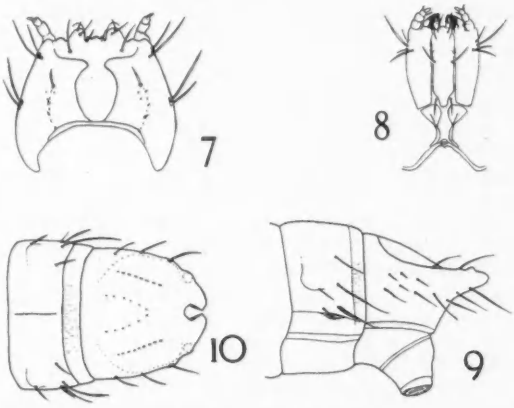

Fig. 7. *Limonius aeneoniger* Larva. Head capsule—dorsal. Fig. 8. Larva. Ventral mouthparts. Fig. 9. Larva. Last abdominal segments—lateral. Fig. 10. Larva. Last abdominal segments—dorsal.

SYMBOLS USED IN ILLUSTRATIONS

ALG.....anterolateral groove.
ANT.....antennae.
C.....cardo.
CSU.....cardinal suture.
CX.....coxa.
DLS.....dorsolateral suture.
FN.....frontoclypeal plate.
FR.....femur.
FS.....frontal suture.
G.....galea.
GEN.....gena.
GU.....gula.
HS.....hypostomal suture.
LAC.....lacinia.
LJ.....“lower jaw.”
LP.....labial palpus.
LPE.....prelabium.
LPO.....postlabium.
MAN.....mandible.
MB.....mandibular brush.
MDL.....distal lobe of mandible.
MPL.....proximal lobe of mandible.
MPS.....maxillary palpus.
MS.....median suture.
N.....nasale.
ND.....nasal depression.
NP.....nasal projection.
NLW.....lateral wing of nasale.
OC.....ocellus.
PCS.....postoccipital suture.
PES.....presternum.
PN.....pronotum.
PS.....pleural suture.
S.....stipes.
SPI.....spiracle.
TD.....tergal disk.
TR.....trochanter.
UH.....horizontal branch of urogomphi.
UV.....vertical branch of urogomphi.
a, b, c, d, e, f, g, h, i....setae of the head capsule.

Postlabium (*LPO*, fig. 2) elongate, closely united to and between stipites. Proximal sclerotized portion two and one-half times as long as wide, suddenly narrowed from both sides near proximal end, bluntly rounded at tip; each angle of reduction occupied by a single long seta. Single long setae on each lateral margin near distal end of sclerotized portion, slightly posterior to setae on stipites. Distal fifth of postlabium white and membranous.

Prelabium (*LPE*, fig. 2) sclerotized on posterior two-thirds, basally approximately one-half width of postlabium, broadened to bases of labial palpi (*LP*) and distal end of prelabial sclerotization, narrowed uniformly thence to small blunt tip. A pair of long setae between bases of palpi and base of prelabium. Distal end of prelabium, especially slightly produced tip, provided with sensory pits, papillae, and short setae.

Labial palpus (*LP*, fig. 2) 2-segmented, cylindrical, with sclerotized bands around each segment, ends white, membranous. Distal segment one-half as wide and two-thirds as long as proximal one. Small setae on proximal segment, papillae on tip of distal one.

PREHYPOPHARYNX membranous, nearly bare in space between hair growths of laciniae, separated from posthypopharynx by transverse, erect growth of hair. Posthypopharynx membranous, posteriorly limited by sclerotized "closing plate," more generally covered with hair than surface of prehypopharynx. Hair growth of preoral cavity heavy.

PROTHORAX (fig. 3) covered dorsally by subrectangular pronotal plate (*PN*), wider than long, heavily sclerotized, dark, with numerous small circular pits separated by from one and one-half to several times their diameters, distinct medial suture (*MS*, fig. 5) its entire length; setae-bearing depressions on each side near both anterior and posterior margins, three near posterior margin as in following segments, those on anterior only on this segment and quite irregular but parallel to margin. Epipleural areas partly membranous, partly fused with pronotal plate or reduced by its expansion.

Episternal area large, triangular, varying in sclerotization and limited by darker pleural suture (*PS*, fig. 3) posteriorly and presternum (*PES*) mesally. Epimeron indistinct. Presternum (*PES*) equilaterally triangular, one point posteriorly on median line. Side of triangle opposite this point forming entire anterior margin of ventral surface of segment, rather firmly attached to head capsule. Pair of long setae near midpoint of lateral margins of presternum; smaller ones forming a sparse row near anterior margin. Other sternal areas largely membranous.

MESOTHORAX AND METATHORAX each approximately one-half length of prothorax and of similar width. Notal shields less darkly colored and less widely sclerotized than pronotum. Small circular pits denser on mesonotum than on pronotum, on metanotum wider, less sharply outlined, more rounding on bottoms. Medial longitudinal suture distinct but less pronounced than on darker pronotum. Two long setae marking each lateral margin of nota. Anterior and posterior laterotergites distinct, former bearing spiracle on mesothorax, each of latter with a long seta near its center. Sterna normal.

LEGS not unusual for genus, coxae nearly contiguous, pairs of coxae separated by approximately length of individual coxa. Coxa (*CX*, fig. 3) oval, only slightly elevated above body wall near pleural suture, ventral surface shallowly depressed for reception of trochanter. Series of short rows totaling about 15 dark-brown, heavy, almost conical spines outlining anterior margin of depression. Trochanter (*TR*, fig. 3)[4] cylindrical, short on side against coxal depression, anterior surface with three rows of dark spines, longest bordering tread surface or solea. Posterior surface with row of spines margining tread, a few scattered ones. Two following segments similar to trochanter in cylindrical form, heavier spine growth on anterior surface outlining tread whose surface is bare except for occasional, long, slender setae; segments gradually reduced in size. Reduced rather suddenly distally to dark, strong, moderately curved, single claw, or ungula.

FIRST TO EIGHTH ABDOMINAL SEGMENTS about as wide as thoracic, approximately one-half as long as wide, but gradually increasing in length to sixth or seventh. Eighth shorter and narrower than those immediately preceding. Tergal shields similar to those of mesothorax and metathorax, sclerotized, rather densely pitted, pits shallow and rounding, three pairs of setae-bearing depressions near posterior margin. A sharply impressed but visually somewhat indistinct remnant of anterolateral groove (*ALG*, fig. 4)—erroneously termed "muscular impression"—consisting of an impressed angle near anterolateral corner of tergite and of a more lateral than transverse groove. The lateral portion may extend one-third the length of the segment. Laterotergites similar to those of last two thoracic segments, anterior laterotergite much the larger, extending nearly entire length of segment, the posterior farther ventrally. Each laterotergite bearing a long seta, these two nearly opposite each other. Sternite narrowed posteriorly by smaller laterotergite, lightly sclerotized, with distant small setae near posterior and lateral margins.

NINTH ABDOMINAL SEGMENT (figs. 4, 5) uniformly narrowed to shortly before vertical branches of urogomphi, then rounded posteriorly. Longest of abdominal segments, it alone longer than wide. Surface densely roughened, but with very few of protuberances commonly found on related forms. Tergal disk (*TD*) nearly round, margined on most of its circumference by distinct elevated ridge; this ridge disappearing medially at anterior end, but continuing posteriorly to vertical branches of urogomphi, then less distinctly along inwardly bent arms of horizontal branches of urogomphi to include expanded portion of "keyhole." Surface of disk anteromedially rather convex, frequently a shallow circular depression near its center. Ventral and lateral surfaces much smoother, with ten or more pairs of setae from inconspicuous pits.

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[4]The musculature of the distal portion of the leg of the larva of *Limonius consimilis* was worked out by Dr. W. H. Anderson of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, and the naming of the segments corrected to conform with the musculature of insects as determined by Mr. R. E. Snodgrass (1935). Grateful acknowledgment is due Dr. Anderson for his careful review of the manuscript and his many helpful suggestions.

Urogomphi paired and branched; each consisting of reduced vertical branch and medially bent horizontal one. Vertical branch (*UV*) a small blunted cone on dorsal surface of horizontal branch, a long seta arising from its top. Horizontal branches (*UH*) approaching mesoposteriorly and nearly enclosing "keyhole," separated by approximately one-fourth lateral measurement of cavity enclosed, the "keyhole." Cavity transverse elongate oval, except where heavily sclerotized horizontal branches cause posterior margin to be nearly straight.

TENTH ABDOMINAL SEGMENT neither greatly reduced nor provided with armature. Quite normal for genus.

SPIRACLES (*SPI*, fig. 4) biforous, situated in membranous area between tergite and anterior laterotergite on each side of each of first eight abdominal segments; small, rather indistinct, without evident sclerite, of typical elaterid form.

COMPARISON OF THE LARVAE OF LIMONIUS AENEONIGER (DEGEER) AND L. CONSIMILIS WALKER

The larva of *Limonius aeneoniger* (Degeer), or of the synonym *L. bructeri* (Panz.) (Schenkling, 1927), has been mentioned and illustrated by Schiödte (1870) and Henriksen (1911) but no detailed description is available, and therefore its characteristics will be mentioned in comparison with those of the larva of *L. consimilis* Walker.

The material of the European larva so kindly loaned for study consisted of two slides and a single partially dissected larva in alcohol. The slides were a mount of a cast skin and one of the larval mandibles. Drawings of the head capsule, dorsal aspect, the ventral mouthparts as dissected out, and the last abdominal segments, dorsal and lateral aspects, are included as figs. 7, 8, 9, and 10. These are based upon the limited material available and may not be entirely typical of the species.

The general appearance of the two larvae is very much the same. The larvae of *Limonius consimilis* have lost much of their brilliant color since being stored in alcohol, and since only a single alcoholic specimen of *L. aeneoniger* is available little can be told as to its coloring when alive and as to individual variations in form.

The head capsules are very similar. The frontal sutures in *Limonius aeneoniger* do not parallel one another for any distance at the point where they approach, therefore the constriction in the fronto-clypeal plate is more elongate in *L. consimilis*. The three teeth of the nasal projection in *L. aeneoniger* appear to arise from a solid projection and not from the level of the nasal

depression as those of *L. consimilis* appear to do. The eye-spots, the short, stubby head, the general form of the fronto-clypeal plate, and the arrangement of the setae are similar. It should be noted that no ocular lens is evident and the cast skin of neither species shows any apparent evidence of the existence of the ocelli. The antennae are similar. The mandibles are compact, stubby, 4-toothed in both species. The only mandibles of *L. aeneoniger* seen are well worn and mounted on a slide, and indicate that the two secondary teeth are both associated with the distal lobe as in *L. consimilis*. The ventral mouth parts are very similar. Distally the lateral margins of the stipites of *L. aeneoniger* are parallel while those of *L. consimilis* continue to diverge slightly. Thus the entire plate in the case of *L. aeneoniger* does not present the wedgelike appearance seen in *L. consimilis*. In neither species has a suture been noted to demark the dististipes but a distinct line marks the change from the sclerotized stipes to the membranous palpifer. The membranous area in the distal portion of the postlabium is large in both species.

The thoracic and abdominal segments are very similar. The setae near the anterior margin of the pronotum appear more regular in size and location in *Limonius aeneoniger* than in *L. consimilis*. In *L. aeneoniger* the dorsalmost of the three depressions on each side is nearly as far posterior to the striated connective membrane as it is from the second depression, while the ventralmost, which completes a straight line with the other two, is in the edge of the connective membrane. In *L. consimilis* the spines are irregularly arranged, not limited to distinct depressions, and the row tends to be parallel to the edge of the connective membrane, and frequently the dorsalmost seta is nearly posterior to its immediate neighbor. The legs are very similar in form, size, and the number of setae present. The antero-lateral grooves of the abdominal tergites are similar, not prominent. The ninth abdominal tergites are similar. Here the greatest difference appears to be in the angle of the horizontal urogomphal branches. In *L. aeneoniger* the tips are directed obliquely backward whereas in *L. consimilis* they are directed nearly mesad. The tergal disks are similar, though the central depression often noted in *L. consimilis* was not seen in the material of *L. aeneoniger* studied. The tergal surfaces in both species were much more coarse than usually seen in *Limonius* larvae.

PHYLOGENY

The larvae of these two species, though very similar, should be readily separated by the form of the constriction of the frontoclypeal plate, by the direction of the tips of the urogomphal branches, and by the arrangement of the setae on the anterior margin of the pronotum. The 4-toothed mandibles separate them from all other known larvae of the genus, while their general appearance and urogomphal characters retain them within the borders of the genus *Limonius* as at present delimited. Though dissimilar to the economic forms, yet as typical of the genus they must serve as a basis for the taxonomic study of the *Limonius* larvae.

These larvae have the labrum and clypeus fused to form a nasale immovably united with the frons and have biforous spiracles, mouth parts not reduced, and dorsal and ventral prothoracic sclerome not united, characters which indicate that they are elaterid larvae (Böving and Craighead, 1931). They are dorsoventrally depressed, have membranous and visible pleural areas, the ninth abdominal segment emarginate posteriorly, the tenth abdominal segment without armature, and the submentum (postlabium) broad posteriorly, and have teeth on the inner surface of the mandibles. These characters show them to belong to the tribe Lepturoidini of the subfamily Pyrophorinae as characterized by Hyslop (1917).

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FIVE NEW SPECIES OF EURYTOMA FROM MEXICO

(Eurytomidae: Hymen.)

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Many chalcid parasites of several families were bred from a collection of Cynipidae, collected by Dr. A. C. Kinsey, of Indiana University, during two expeditions into Mexico in the falls of 1931 and 1935. The family Eurytomidae was well represented by large numbers of two genera (*Decatoma* and *Eurytoma*). About 1300 specimens of *Eurytoma* have been studied and in the following pages five new species are described.

The fact that these wasps are parasitic on, among many other hosts, gall making Cynipidae makes available their host relations as additional data for the taxonomist. A very close correlation was found to exist between the five species described herein and their cynipid hosts. For instance, each of the five parasitic species occurs on a distinct cynipid host of the genus *Amphibolips*.

Three of the five new species of parasites (*E. mucronura*, *E. tenuis* and *E. acus*) occur in separate but neighboring localities. A fourth species (*E. flavocoxa*) occurs at the same locality and on the same species of black-oak as one of the others (*E. mucronura*), but is quite distinct and, correlated with this, is its occurrence on a distinct although as yet undescribed cynipid host. It is probably a host segregate. The fifth species, (*E. laxitas*) occupies a distant locality from the other four and is quite different from them. Additional data to aid in defining the affinities of the parasites might be contributed from the black oaks of Mexico, but to my knowledge their relationships have never been clearly established. All five parasitic species emerge in the spring of the year. They all occur at rather high altitudes, ranging from 7,700 feet to 8,500 feet.

The species range through the central part of Mexico on the slopes of the western Sierra. (Map.)

The five new species appear to represent such a close-knit unit that some way of indicating their close relationship seems necessary. However, it does not seem wise to give them a categorical rank until more material is available from Mexico

and until a revision of the whole genus over its entire range can be made. Temporarily, therefore, they will be referred to as the *Mucronura* group in order to distinguish them from at least two other distinct groups from Mexico which contain new species to be described in later publications.

The five species can be further divided into two groups or complexes as illustrated in Map. The four sepcies to the south appear to be closely related structurally as well as

Map showing known range of five new species of Eurytoma from Mexico

geographically, indicating a similar evolutionary origin, and have been placed in the *mucronura* complex. The fifth species (*E. laxitas*) to the north, however, is quite distinct structurally from the other four and in order to indicate its different evolutionary path it has been assigned to a second complex (*laxitas* complex). Additional confirmation of this distinction is afforded by the fact that Kinsey (1937) places its (*E. laxitas*) host in a complex (*Amphibolips niger*) separate from the others. It is still, however, more closely related to the four species mentioned above than to any other species in the Mexican material which yet remain to be described.

A search of the literature has revealed only four species previously described from Mexico, *Eurytoma tepicensis* Ashmead (1895), *E. auriceps saminatrix* Walsh (1870), *Bruchophagus herrerae* Ashmead (1902) which, according to Gahan (1932) is the same as *E. tylodermatis* Ashmead (1896) and *E. compressa* Bugbee (1939). I have either seen determined specimens which were compared with types, or had my own material compared with the types of all the species mentioned above. None of them, even remotely, show any relationship to any of the five new species described below.

For an interpretation of any of the structures used in the descriptions of the species, reference to my paper on the *Phylogeny of Some Eurytomid Genera* (Bugbee, 1936) would clear up the terminology and names of various parts.

KEY TO THE NEW COMPLEXES AND SPECIES OF THE GENUS EURYTOMA FROM MEXICO

A. Abdomen oval from a lateral view; lateral compression not extreme; depth of the abdomen equal to about 1½ times the width; exposed posterior portion of the dorsal valves ranges in length from .24 to .35 mm., with an average of .32 mm.; posterior dorsal edge of the sixth abdominal segment not or only very slightly emarginate.....**MUCRONURA** complex

b. Dorsal valves of the female genitalia not the same width throughout horizontal length but with a concavity immediately anterior to the exposed tip (See drawings 1 and 3).

c. Horizontal part of dorsal valves anterior to the concavity broad and stout and with a bulge medially; males with the coxa all black (See drawing 1).....**E. mucronura**

cc. Horizontal part of dorsal valves anterior to concavity thin, not stout, and without a bulge medially; males show yellow fore-coxae and often yellowish tinge to mid-coxae (See drawing 3).....**E. flavocoxa**

bb. Dorsal valves of the female genitalia, with exception of exposed tip, same width throughout horizontal length or at least no noticeable concavity anterior to exposed tip (See drawings 5 and 7).

c. Wing veins heavy and stout; marginal vein equal to about 3 times the length of the postmarginal vein; rear dorsal edge of abdominal segment 6 only slightly emarginate.....**E. tenuis**

cc. Wing veins moderately stout; marginal vein equal to about 2 times the length of the postmarginal; rear dorsal edge of abdominal segment 6 mediumly emarginate.....**E. acus**

AA. Abdomen deeply oval in outline and exhibiting considerable lateral compression; the depth of the abdomen equal to about twice the width; exposed posterior end of the dorsal valves long and pointed, averaging about .65 mm. in length; posterior dorsal edge of abdominal segment 6 deeply emarginate.....**LAXITAS** complex—**E. laxitas**

MUCRONURA COMPLEX, NEW COMPLEX

Figs. 1–8

Female.—Length from 2.8 to 4 mm. averaging about 3.6 mm. All species smaller than in the *Laxitas* complex. Abdomen oval from the side; the width as seen from above averaging about .70 mm. and the depth as seen from the side about 1.0 mm.; thus the depth is equal to

about one and one-half times the width; posterior, exposed portion of the dorsal valves ranges in length from .24 to .35 mm., averaging about .32 mm.; segment 6 from the side wider than segments 4 and 5 combined; dorsal, posterior edge of segment 6 not or only slightly emarginate; total length of internal genitalia averages about 2.1 mm. Coxa black. Legs reddish brown with lemon yellow tips and with or without varying amounts of black infuscation on femurs and tibias. Width of the head including eyes, from above, ranges from 1.5–2.1 mm.; average 1.8 mm.; eyes not greatly bulgy laterally; head from above flat to rounded in front; a shallow, triangular pit may or may not be present below the eye. Front ocellus often surrounded by a distinct oval or diamond shaped area. Marginal and postmarginal veins dark brown in color and stout; marginal vein averages about 2.4 times the length of the postmarginal; wings relatively long, 1.22 to 1.33 of body in length.

Hosts.—Amphibolips species on black oaks (*Quercus Rossii*, *Q. serrulata*, and *Q. Eduardi*).

Range.—West central part of Mexico on the slopes of the western Sierra. Known from the states of Jalisco, Michoacán, and Zacatecas. (See Map.)

Altitude.—7,700 to 8,500 feet.

The *mucronura* complex contains 4 species described in the following pages. The more oval abdomen with less lateral compression; shorter exposed portion of the dorsal valves with a less acute upward tilt; smaller size, and slight, if any, emargination of the posterior dorsal edge of segment 6 help to distinguish this complex from the *Laxitas* complex.

Eurytoma mucronura New Species
(MUCRONURA complex)

Figs. 1 and 2

Female.—Length, 3 to 4 mm.; average 3.5 mm.; abdomen broadly oval from the side; depth from the side averages 1.0 mm.; width from above .70 mm.; the depth thus averages about one and one-half times the width; the posterior, exposed tip of the dorsal edge of segment 6 may or may not show slight emargination from above; total length of internal genitalia averages about 2.2 mm.; anterior extension of dorsal valves broader than in other species of this complex; and with a noticeable bulge towards the middle; thus it does not retain same width relations throughout its length; exposed, posterior tip of ventral valves may be all black or with small amount of reddish brown cephalad of tips; dorsal abdomen smooth and shiny black; scaling covering lower half of the lateral aspect of segment 6. Legs with the coxa black; rest of legs light reddish brown shading into lemon yellow on the tips of the femurs and tibia; in most cases black splotches on fore and mid-femurs and none on hind-femurs; in a few some black infuscation may be present on hind-femur; all tibia most often with black medially; usually greatest amount on mid-tibia where it encircles tibia rather than appearing as a splotch on outer

surface only; in a few cases no black may be present on legs at all. Head from above bulges some between the eyes; width equal to 1.1 mm. and length to .47 mm.; eyes not noticeably bulgy laterally; front ocellus usually surrounded by a large diamond shaped area which is finely pitted around edge. Antenna subclavate; scape mostly black with a slight amount of reddish brown basally. Marginal vein about 2.3 times length of postmarginal; postmarginal thick basally but tapers to a point at outer end; stigmal club elongate and flat to gently rounded basally; wings relatively long, 1.30 of body in length.

Males.—Length, 2 to 3.5 mm.; average 2.5 mm. More black on all legs than in female, especially on hind-femur and tibia where black covers most of femur leaving lemon yellow tips only; medial part of tibia encircled by black infuscation; coxa all black.

Types.—53 females and 13 males; holotype female and allotype male along with paratypes of both sexes in Bugbee collection; paratypes of both sexes in the National Museum.

Type locality.—Labels read: Purépero, 5 miles west, Michoacán, Mexico; 8,500 feet; galls December 25, 1931, males and females, spring of 1932.

Hosts.—Labels read, *Amphibolips nassa* Kinsey det., *Quercus serrulata*, Kinsey coll. For description of the gall and gall maker, see Kinsey, 1937.

Range.—The range of its host (*Amphibolips nassa*) is given by Kinsey (1937) as probably extending throughout a wide area in southwestern Mexico, including Michoacán and Jalisco. It is probable that the parasite will cover much the same range.

E. mucronura appears to be closely related to the next species, *E. flavocoxa*. Its larger size, greater quantities of black infuscation on the legs and larger, differently shaped head, are good distinguishing features. The black coxa of the males of *E. mucronura* also aid in separating them from the males of *E. flavocoxa* which have yellow fore and mid-coxa.

Eurytoma flavocoxa n. sp.

(MUCRONURA complex)

Figs. 3 and 4

Females.—Length, 2.8 to 3.5 mm.; average, 3.2 mm. Abdomen oval from the side; depth equal to .90 mm.; width to .60 mm.; depth thus equal to about one and one-half times the width; shiny black above with rather coarse scaling towards the base of segment 6 which covers about one-half to two-thirds of its lateral surface; posterior, exposed portion of dorsal valves averaging .24 mm. in length; dorsal, posterior edge of segment 6 not or only very slightly emarginate from above; posterior end of ventral valves black or with small amount of deep reddish brown coloring. Legs with the coxa black; basic color of

femurs reddish brown; all show presence of black splotches, however, and their tips are lemon yellow; most often black splotches on all tibia but occasionally none on hind-tibia. Head appears small but well rounded in front; width equal to .87 mm. and length to .35 mm.; eyes not bulgy laterally; front ocellus surrounded by an elliptical to diamond shaped area; maybe a very small shallow pit below eye. Antenna subclavate; joints cylindrical with a suggestion that some of them may tend to be moniliform; scape with lower one-half to one-third yellow; rest black; pedicle small and rounded like a bead. Wing veins dark brown, stout; marginal equal to about 2.2 times the length of post-marginal; stigmal club may be flat or very slightly rounded basally. Wing body ratio is 1.33.

Male.—Average length is 2.6 mm. Legs straw yellow in most cases with no sign of black infuscation on femurs or tibia; in a few cases slight black splotches may appear on some femurs and tibia; front-coxa usually all yellow or with small amount of black on anterior and lateral faces; also yellowish tinge on mid-coxa of most; hind-coxa black.

Types.—11 females and 5 males. Holotype female and allotype male and paratype males and females in Bugbee collection; paratypes of both sexes in United States National Museum.

Type locality.—Labels read, Purépero, 5 miles west, Michoacán, Mexico, 8,500 feet; galls December 25, 1931.

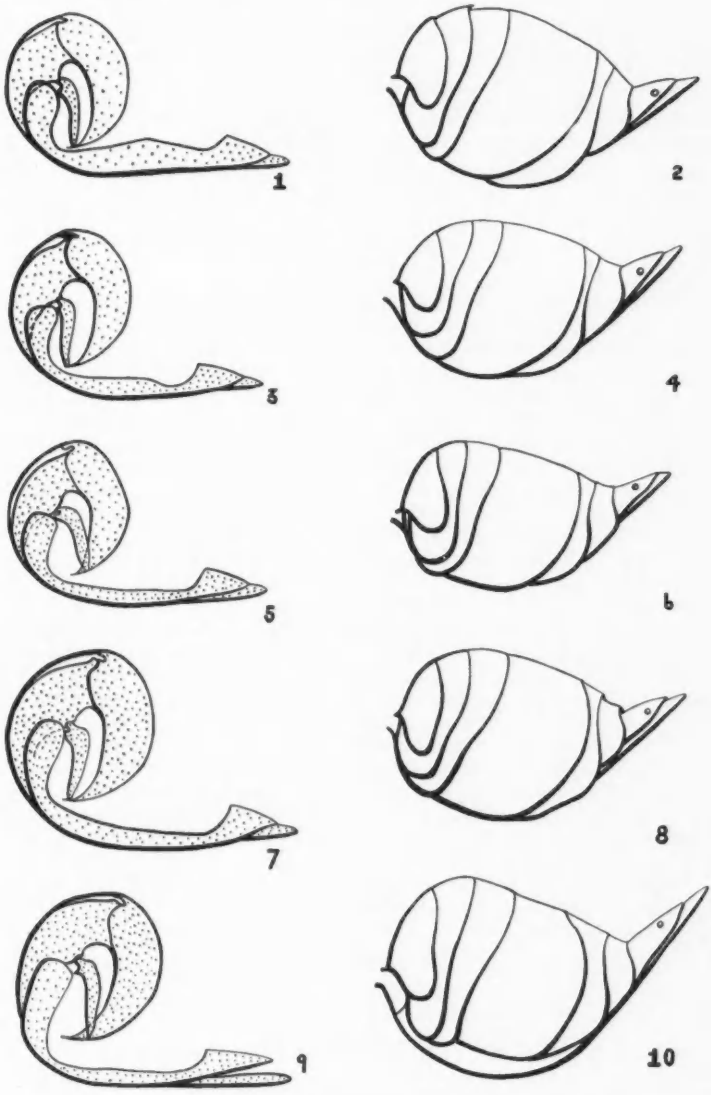
Hosts.—Labels read, undetermined species of *Amphibolips*, Kinsey det.; *Quercus serrulata*, Kinsey coll.

Range.— Known only from Purépero in the state of Michoacán, located in the west central part of Mexico.

This species is most closely related to *E. mucronura*. Both occur in the same territory and are very much alike but *E. flavocoxa* is found on a different gall-making host of the genus *Amphibolips* which is as yet undescribed. When the two species are compared, *E. flavocoxa* is noticeably smaller and less bulky. The smaller, rounded head; presence of some black always on the hind femur; the longer appearing abdomen which is not as deep as in *E. mucronura*, help to separate the two. If *E. flavocoxa* males are available the yellow fore and mid-coxa and the total lack or only small amount of black on femurs and tibia as opposed to the black coxa of the males of *E.*

EXPLANATION OF PLATE I

Fig. 1. Genitalia of *Eurytoma mucronura* n. sp. Fig. 2. Abdomen of *Eurytoma mucronura* n. sp. Fig. 3. Genitalia of *Eurytoma flavocoxa* n. sp. Fig. 4. Abdomen of *Eurytoma flavocoxa* n. sp. Fig. 5. Genitalia of *Eurytoma tenuis* n. sp. Fig. 6. Abdomen of *Eurytoma tenuis* n. sp. Fig. 7. Genitalia of *Eurytoma acus* n. sp. Fig. 8. Abdomen of *Eurytoma acus* n. sp. Fig. 9. Genitalia of *Eurytoma laxitas* n. sp. Fig. 10. Abdomen of *Eurytoma laxitas* n. sp.



Genitalia and Abdomens of Five New Species of the Genus *Eurytoma* from Mexico

mucronura are good differentiating characters. The fact that the two species occur in the same territory on the same oak host and that they are fairly close together morphologically suggests that they represent host isolates. The host of *E. mucronura* is *Amphibolips nassa* Kinsey which occurs on *Quercus serrulata* while *E. flavocoxa* parasitizes an as yet undescribed *Amphibolips* species on *Quercus serrulata*.

Eurytoma tenuis n. sp.
(MUCRONURA complex)
Figs. 5 and 6

Female.—Length, 3.5 to 4.1 mm.; average, 3.8 mm. Abdomen is elliptical or oblong in outline from the side rather than oval; depth averages 1.1 mm.; width .75 mm.; scaling on segment 6 covers one-half to two-thirds of lateral aspect; posterior, exposed portion of dorsal valves averages about .30 mm. in length; internal genitalia have an average total length of 1.9 mm.; the anterior extension of the dorsal valves is narrow and maintains the same width until it turns at right angles, dorsally; anterior, dorsal extension of the ventral valves is a broad plate but not as broad and heavy as in the other species of this complex; ovipositor tips reddish brown; rear, dorsal edge of segment 6 not or only slightly emarginate from above. Legs with the coxa black; rest of legs reddish brown with yellow tips on femurs and tibias; black infuscation present as splotches on femurs and tibia; black may be absent on fore and hind-femurs and on mid- and hind-tibia in some; usually present on mid-femur and mid-tibia where it encircles whole tibia. Head rounded in front from above; width averages 1.7 mm. and length .75 mm.; eyes not bulgy laterally; front ocellus placed in a noticeable diamond to elliptical shaped area. Antenna subclavate; basal one-half to one-third of scape reddish brown, rest black. Wing veins dark brown in color and very stout; postmarginal vein broad at base and truncate at outer end; margin about three times the length of the postmarginal; stigmal club small but rounded semi-deeply basally; whole wing broader than in the other species of the mucronura complex; wing body ratio of 1.27.

Types.—11 females; no males. Holotype and paratype females in Bugbee collection; paratype females in U. S. National Museum.

Type locality.—Labels read, Sayula 13 miles southwest, Jalisco, Mexico, 7,700 feet; galls, December 21, 1931; females spring of 1932.

Hosts.—Labels read, undescribed species of *Amphibolips confluentus* complex Kinsey det.; *Quercus rossii* Kinsey coll.

Range.—Known only from Sayula in the state of Jalisco.

This species seems to have its closest relative in *E. mucronura* from Purépero in the neighboring state of Michoacán to the

south. It differs from *E. mucronura*, however, in the following ways: slightly larger size; elliptical shape of the abdomen; narrow, uniform width of the dorsal valves; stouter marginal and postmarginal veins and the shorter postmarginal in relation to the length of the marginal. In addition to the above it occurs on a different although as yet undescribed gall making host on a distinct species of black oak.

Eurytoma acus n. sp.
(MUCRONURA complex)
Figs. 7 and 8

Female.—Length, 3.6 to 4 mm.; average, 3.8 mm. Abdomen broadly oval in outline from the side; depth averages 1.2 mm.; width .75 mm.; scaling on lateral surface of segment 6 covers about two-thirds to three-fourths of lower surface; posterior, exposed portion of the dorsal valves averages .32 mm. in length; internal genitalia have a total average length of 2.1 mm.; anterior extension of the dorsal valves is long and narrow, maintaining same width until they turn dorsally; dorsal extension of ventral valves expands into a broad plate and bends posteriorly more so than in other species of the *mucronura* complex; tips of the ovipositor sheaths reddish brown; rear dorsal edge of segment 6 slightly to mediumly emarginate from above. Legs with the coxa black; basic color of rest of legs reddish brown; considerable black on all femurs and tibia; two-thirds of fore-femur covered by black splotch which flares up from base on outer surface; less amount on mid-femur; most of hind-femur covered with black leaving only lemon yellow tips; black medially on all tibia, but greatest amount on mdi-tibia. Head flat across front from above; width equal to 2.1 mm.; length to .85 mm.; eyes bulgy laterally; front ocellus may be placed in an indistinct diamond to elliptical shaped area. Antenna pointed; scape with lower one-fourth reddish brown; rest black. Wing veins brown to dark brown and mediumly stout; marginal equal to twice the length of postmarginal, stigmal club quite small and either flat or rounded basally. Wing body ratio equal to 1.22.

Males.—Length, 3–3.8 mm.; average of 3.3 mm. Coxa black; black on all femurs increasing in amount from front to rear; black on most tibia; front tibia may lack it in some cases.

Types.—23 females and 23 males. Holotype female, allotype male and paratypes in Bugbee collection; paratypes of both sexes in U. S. National Museum.

Type locality.—Labels read, Zacatecas 22 miles southwest, Zacatecas, Mexico; galls November 22, 1931; males and females spring, 1932.

Hosts.—Labels read, *Amphibolips fusus* Kinsey det. *Quercus Eduardi* Kinsey coll. For description of gall and gall maker see Kinsey, 1937.

Range.— Known only from Zacatecas in the state of Zacatecas. Kinsey (1937) states that its host is "probably restricted to a central portion of the Western Sierra of Mexico, including the state of Zacatecas." The parasite will probably cover the same territory.

Eurytoma acus seems to be closest to *E. tenuis* from Sayula, Mexico. In color distribution on the legs, size and wing body ratio, the two resemble each other. However, the two diverge distinctly; in depth and width relations of the abdomen; the shorter postmarginal vein in relation to marginal of *E. acus;* its wider head, more bulgy eyes, and different gall making host on a separate species of black oak.

In several respects (i. e., head dimensions and extensive black infuscation on legs) *E. acus* resembles *E. laxitas* of the following *laxitas* complex. Possibly the *mucronura* complex thus grades through *E. acus* into the *laxitas* complex. The two are, however, easily separated on the basis of the numerous characters listed after the description of *E. laxitas*.

LAXITAS COMPLEX, NEW COMPLEX

Only one species is recognized so far in this complex so that its specific description also represents the known limits of the complex.

Eurytoma laxitas n. sp.

(LAXITAS complex)

Figs. 9 and 10

Map

Female.—Length, 4.6 to 5.2 mm.; average, 4.9 mm.; largest of the five species described. Abdomen is deeply oval in outline; lateral compression considerable, width being equal to .90 mm. and the depth equaling 1.8 mm.; the depth thus is equal to about twice the width; scaling on segment 6 covers about two-thirds of lateral surface; coarse at base but plays out dorsally; dorsal, posterior edge of segment 6 deeply emarginate from above; exposed, posterior end of dorsal valves elongate and pointed; averaging about .65 mm. in length and, with the ovipositor sheaths, directed upward; total length of internal genitalia averages 2.7 mm.; anterior extension of dorsal valves narrow and uniform in width until they turn dorsally; dorsal extension of ventral valves broad and bent posteriorly; whole anterior region of genitalia appears as though it was going to coil on itself like a watch spring. Legs with femurs all black except tips which shade from reddish brown to lemon yellow; black infuscation medially on all tibia with greatest amount on mid-tibia; tips lemon yellow. Width of head from above, including the eyes, averages about 2.5 mm.; flat in front and eyes bulgy laterally;

front ocellus may be surrounded by a very small, indistinct circular to oval area; not noticeable in many; no pit below eye. Scape of antenna with the lower one-fifth or less, yellowish brown; rest of scape black. Marginal and postmarginal veins short and stout; marginal averages about 2.1 times the length of the postmarginal; stigmal club small and rounded basally but not deeply; wings relatively short, averaging 1.55 of body in length.

Types.—6 females. Holotype and paratype females in Bugbee collection and paratype females in U. S. National Museum.

Type locality.—Labels read, Otinapa, state of Durango, Mexico, 8,500 feet; galls November 14, 1931; females spring, 1932.

Hosts.—Labels read, *Amphibolips* (*niger*) *jubatus*, Kinsey det. *Quercus fulva*, Kinsey coll. For description of the host and gall from which the parasitic species was bred see Kinsey, 1937.

Range.—Collected in the southwestern corner of the state of Durango. Its host, however, according to Kinsey (1937) is "confined to the state of Durango" so that further collections would probably extend the range of the parasite accordingly. (See Map).

This species superficially resembles *Eurytoma acus* of the preceding complex from Zacatecas in the neighboring state of Zacatecas. Head width and length, color distribution on the legs and size are much the same in both. However, further collections from areas to the north or south in the future may reveal much closer affinities to as yet undiscovered species, as it still seems considerably removed from *E. acus* as well as the whole *mucronura* complex, in the following ways: much greater depth and different shape of the abdomen; more elongate, posterior tips of dorsal valves; deep emargination of dorsal posterior edge of segment 6; the relatively shorter wings in relation to the body length and finally, their separate ranges and distinct host species. Furthermore, both *E. laxitas* and its cynipid host are placed in different complexes which implies that they are not closely related.

Correlation with the host data is very close in the five species just described. In other cases in this same genus, however, host restriction is not so clearly defined. This, however, does not invalidate the use of such data where it can be used by the taxonomist. We do not expect the evolution of one group to parallel in any or all of its phases the evolution

of other groups. Each group and individual is a law unto itself. This is especially true with free-living organisms. It is true, nevertheless, that more correlation has been found and would logically be expected between parasites and hosts, because of their intimate relations established over a long period of time (*Cynipidae* and oaks, Kinsey, 1930 and 1936; *Eurytomidae; Harmolita* and grass species, Philips and Emery, 1919, and Philips, 1936; *Termites* and *Staphylinidae*, Emerson, 1935, etc.). Thus in many cases different host species often help to distinguish distinct parasitic species, and visa versa. In other cases parasitic species may use several related hosts and still again many unrelated hosts. In the genus *Eurytoma* for instance, *E. rhois* Crosby (Bugbee, 1939) is reported from three closely related sumac hosts (*Rhus glabra, R. typhina* and *R. copallina*). *E. appendigaster* Swederus has been reported from Lepidopterous and Hymenopterous hosts and *E. tylodermatis* Ashmead from Coleopterous, Hymenopterous, and Lepidopterous hosts. Instances of extreme host restriction, as in the five new species mentioned above, as well as considerable latitude in choice of hosts thus may occur side by side within the same genus.

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AESHNA (CORYPHAESCHNA) LUTEIPENNIS AND ITS SUBSPECIES

(Odonata: Aeshnidae)

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In 1839, Burmeister described *Aeschna luteipennis* ♂ "Aus Brasilien, in Sommer's Sammlung." He had two specimens, according to Hagen (1867): "Ich besitze eine der beiden Typen Burmeister's aus Sommer's Sammlung." This specimen was seen by the present writer in 1897 at the Museum of Comparative Zoology, Cambridge, Massachusetts, and the existence of the other at Vienna was certified by Brauer *in litt.* July 15, 1898 (Calvert 1898, pp. 53, 94).

In the Smithsonian Institution's "Synopsis of the Neuroptera of North America" of 1861, Hagen described *Aeschna florida*, from the female only, giving as habitat "Mexico (Deppe)," and remarking "It is most like *Ae. luteipennis* Burm." Prof. Cockerell, writing of bees[1], quoted Prof. E. Strand to the effect that "Ferdinand Deppe sent to the Berlin Museum in 1829 specimens from the following localities: Temascaltepek; Real Ariba; Oaxaca; Vallereal; Rio Alvarado." It is possible, therefore, that the type of *Aeschna florida* is in the Berlin Museum, as Hagen had material from that source when composing the Synopsis of 1861 (p. vi). Muttkowski, Catalogue of the Odonata of North America (Bull. Publ. Mus. Milwaukee I, 1, 1910), page 112, says that the type of *florida* is in the M. C. Z. Mr. Nathan Banks writes me from the Museum of Comparative Zoology, April 20, 1941: "We do not have a type of *Aeschna florida* Hagen; many of our Odonata types were marked by Henshaw, but there is no card for it, which would be present if he catalogued it. Some people take it for granted that the types of Hagen species are here as a matter of course."

In 1865, Brauer described *Aeschna excisa* from males from Brazil and gave a much fuller description and figures of the terminal abdominal appendages in the following year (1866). The number of individuals examined is not stated, but in the

[1]Ann. & Mag. Nat. Hist. (8) 6: 284, Sept., 1910. Horn u. Kahle, Über entomologische Sammlungen, Entomologen & Entomo-Museologie, Ent. Beihefte, Berlin-Dahlem, 2–4; 54, 1935–1937, say "Deppe, Ferdinand Ins.-Ausbeuten aus Mexico (1826–30) ex parte an Zool. Mus. Berlin."

description of 1866, "reifen Individuen" and "jüngere Exemplare" are mentioned. He considered *excisa* to be allied to *Ae. viridis* Rambur, but added: "doch fehlen bei Ramb. die Beschreibung der *Appendices* und die Angabe des Vaterlandes. Das Exemplar Rambur's war schadhaft, es ist daher nicht möglich mit Sicherheit eine Bestimmung durchzuführen." Brauer did not recognize the identity of his *excisa* with Burmeister's *luteipennis*, which may mean that one of the latter's cotypes was not at that time in Vienna, as Sommer did not die until 1868.[2] The "zweifellos[e] Identität" of Brauer's and Burmeister's species was asserted by Hagen (1867), who gave also a description of a *luteipennis* female from "San Leopoldo in Süd-Brasilien."

No additions to the knowledge of this species or its geographical distribution were published for nearly thirty years. In October, 1893, Dr. Gustav Eisen collected one male at Mesa Verde and one at San José del Cabo, Baja California, Mexico, and in September, 1894, with Mr. Frank H. Vaslit, a third male at Miraflores, in the same Territory. In October, 1894, he obtained a male at Tepic, on the Mexican mainland. All four were reported as *luteipennis* by the present writer in 1895 and 1899. The San José del Cabo, Miraflores and Tepic specimens were presumably destroyed in the San Francisco fire of 1906; that from Mesa Verde is at the Academy of Natural Sciences of Philadelphia.

In 1905, Guadalajara (1 ♀), Jalapa (1 ♀) and Cuernavaca (1 ♂) were added to the Mexican localities, San Geronimo, 3000 feet, (1 ♂) for Guatemala, Cachí (1 ♂) for Costa Rica, Chapada (1 ♀), Canta Gallo (1 ♂) and São Paulo (1 ♀) for Brazil, all under the caption *Aeshna luteipennis* (Calvert 1905). In the Supplement to the same volume (1907), material was recorded from Ocotlan and Chapala in Mexico, San José and Juan Viñas in Costa Rica.

In 1908, Martin gave a description and figures of the abdominal appendages of *luteipennis* male, but added nothing on the geographical distribution of the species.

In 1911 Navás described a new genus and species from a pair taken in copula at São Paulo, Brazil, in March, 1910, as *Remartinia barbiellina*, figuring the apex of the abdomen and

[2]Calvert 1898, p. 29. Henriksen, Ent. Meddel. 15 (4): 165–166, with portrait, 1925. Horn u. Schenkling, Index Litt. Ent. 4: 1151, 1929. Horn u. Kahle, Ent. Beihefte 2–4: 263, 402–404, 1935–1937.

the base of the hind wing of the male. In 1918, Ris referred this species to *luteipennis*, with which Navás's description well agrees, although the apex of the superior appendages is shown as more acute than in specimens from S. Paulo at hand. In 1935, Navás, in a list of Colombian Odonata, included "*Coryphaeschna luteipennis*" from Villavicencio.

In 1918, Ris added Misantla, Vera Cruz, Mexico, Rio Aguacatal, 2000 meters, and San Antonio, 1800 m., Colombia, and Espirito Santo, Province of Rio Janeiro, and Santa Cruz, Rio Grande do Sul, Brazil, to the list of localities for *luteipennis*. (Infernillo, Costa Rica, which he mentions also, is an older name for Juan Viñas.)

Thirty years to the month after Eisen collected *luteipennis* in Baja California, the same region was visited by Mr. Jesse H. Williamson (October, 1923), who took this species at Los Parres and San José de Comandu (Williamson 1930).

A larger number of specimens (26 ♂, 9 ♀) of this species being now before me than at any time in the past, as part of a general study of the neotropical species of *Aeshna* and *Coryphaeschna*, and in view of the interesting discovery of a new species related to *luteipennis*, of which Prof. Kennedy is about to publish a description, I have compared minutely the individuals from different localities. The differences which have thus revealed themselves are astonishingly slight, when one considers that the farthest northwestern locality known for the species is 5600 miles (9000 km.) distant from the most southeastern. The chief differences found are in the details of the superior abdominal appendages of the males and are represented in the accompanying figures 2–9. They may be grouped into three lots, viz.: (1) figs. 2–3; (2) 4–7, (3) 8–9. Figs. 1–3 are from Brazil: all the Brazilian males before me and Brauer's figures of *excisa* agree with them. Figs. 4–7 show the form presented by all the males from Panama, Costa Rica and the Mexican mainland. Figs. 8 and 9 are from the two males now available from Baja California; my figure of 1895 also agrees.

A comparison of figs. 2–9 shows that the principal differences are in (1) the inferior apical angle, which is rounded off in the Brazilians (figs. 2–3) and is distinctly angular in the remaining figures; (2) the apical margin is more convex in the Brazilians, but tends to be straight or slightly concave in the others; (3) the distance from the distal angle *o* of the internal emargination

to the apex of the appendage is absolutely and relatively greatest in the examples from Baja California (figs. 8, 9). These differences seem, therefore, to be correlated geographically.

I find no constant color differences and no difference in the penis and genital armature of the second abdominal segment of the males throughout the whole series from Baja California to Santa Catharina, Brazil. Such individual variations as exist in the wing venation are not geographical; the range of variation is practically the same in the Mexican, in the Costa Rican and in the Brazilian material which I have before me.

The series seems undoubtedly to be one species on morphological grounds and no other kind of evidence exists as yet to furnish data for splitting up this "species" into two or more. Yet it may be convenient to have handles for designating the geographical races or subspecies which the shapes of the superior appendages seem to suggest. Here the use of trinomials, in spite of the most recent warning[3] concerning them, seems thoroughly justified. The typical, originally described, form is that from Brazil and must consequently be known as

1. Aeshna (Coryphaeschna) luteipennis luteipennis Burmeister 1839

It has appendages in the male as shown in figs. 1–3. The female may, perhaps, be recognized by the sculpture of the sternum of abdominal segment 2 which has, near its anterior end, a pair of transversely elongated smooth, hairless swellings, almost continuous across the median line; mesal portions with short, mostly whitish hairs, such as occur also, together with long black hairs, on other parts of the same sternum. (These swellings appear to correspond to the posterior margins of the two areas described later for the female of *luteipennis florida*.) See fig. 10. The black T-spot on the upper surface of the frons is always present in both sexes, as far as known.

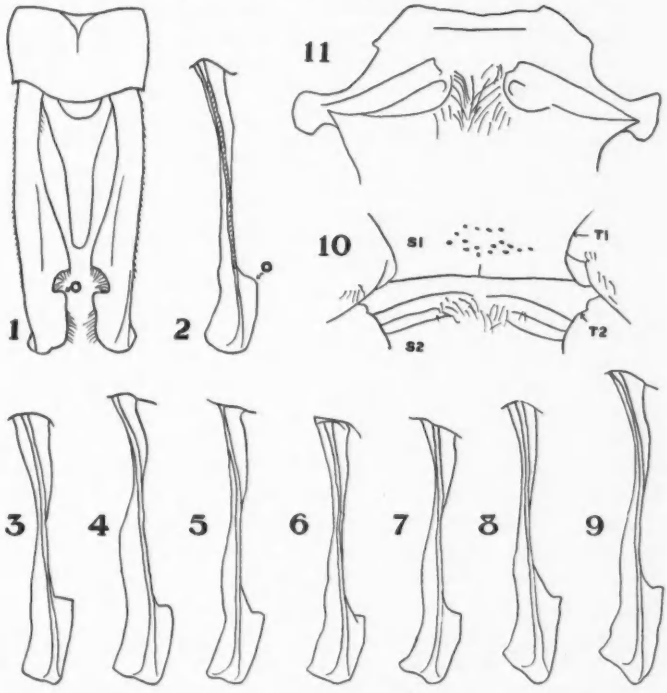
The type of this species is one of the two cotypes of Burmeister. As no lectotype[4] has been designated, to the best of my knowledge, I select the cotype at the Museum of Comparative Zoology as the lectotype. From what locality in Brazil the cotypes came is, unfortunately, unknown.

The material before me which I refer to this subspecies is Canta Gallo, Dr. Teuscher, Thayer Expedition, 1 ♂, Mus. Comp. Zool. São Paulo, August 5, 1900, A. Hempel, 1 ♀, Acad. Nat. Sci. Phila., and 3 ♂, 1 ♀, Coll. John Cowley (England) (1 ♂ and the ♀ labeled Mar. 1937 F. Wucherpfennig). Santos, V. 20, 1919, 1 ♂, Amer. Mus. Nat. Hist. New York.

[3]Cole, Science 93 (2414): 318, April 4, 1941.

[4]Following the usage of Cresson, Ent. News 45 (5): 124, 1934.

Figs. 1–3, 10. *Aeshna* (*Coryphaeschna*) *luteipennis luteipennis* Burmeister.
Figs. 4–7, 11. *Aeshna* (*Coryphaeschna*) *luteipennis florida* (Hagen).
Figs. 8–9. *Aeshna* (*Coryphaeschna*) *luteipennis peninsularis* n. subsp.



1. Dorsal view of abdominal segment 10 and appendages, ♂, Canta Gallo, Brazil. 2–9. Left superior appendage, ♂, viewed laterally in such position that the widest part of the appendage shown in fig. 1 is in the same plane as the line of vision; *a* the distal angle of the excision in the inner (mesal) margin. In fig. 1 the lateral margin of each superior appendage is shown as bearing a row of short hairs; these hairs are shown on the corresponding margin in fig. 2, but are omitted from figs. 3–9.

2. Nova Teutonia, Santa Catharina, Brazil, March 13, 1936. 3. São Paulo, Brazil, March, 1937. 4. Volcan Chiriqui, Panama, Feb. 29, 1936. 5. Juan Viñas, Costa Rica, 3400 ft., June 23, 1909. 6. Cuernavaca, Morelos, Mexico, June. 7. Laguna Ochomogo, Costa Rica, 5000 ft., Sept. 29, 1909. 8. Mesa Verde, Baja California, Oct., 1893. 9. Los Parres, Baja California, Oct. 7, 1923.

10. Hind part of abdominal segment 1 and fore part of segment 2, ventral view, ♀, São Paulo, Brazil, March, 1937; *S*1 sternum of 1 bearing a median cluster of 17 fine denticles; *S*2 sternum of 2 with a transversely elongated swelling from side to side; *T*1, *T*2 lower (ventral) margins of tergites of 1 and 2 which cover the lateral parts of their respective sterna.

11. Fore part of sternum of abdominal segment 2, ventral view, ♀, showing the pair of smooth areas, Las Concavas, Costa Rica, Oct. 12, 1914. This sternum has been detached from the remainder of the abdomen and hence is not covered by any tergites.

All the figures are on the same scale, x 7. Fig. 1 tracing from drawing by Miss Elsie Lincoln, the others by P. P. Calvert.

Nova Teutonia, Santa Catharina, 13 Mar. 1936, F. Plaumann, 1 ♂, Coll. P. P. Calvert. All these localities are in Brazil.

The dimensions of this material are: Abdomen (excl. apps.) ♂ 49–54, ♀ 57, 60; apps. ♂ 5.07–6.22, ♀ 1.06, 1.55; hind wing ♂ 45–46.5, ♀ 47, 49; stigma of front wing,[5] ♂ 3.68–4.09, ♀ 3.80, 4.17 mm.

2. Aeshna (Coryphaeschna) luteipennis florida (Hagen 1861)

The superior appendages of the male are as shown in our figs. 4–7. The female has the sternum of abdominal segment 2, near its anterior end, with a pair of shallow, transversely elongated, smooth areas, each terminated mesally by a slight, curvilinear, pale-haired elevation (convex mesally, concave laterally) which is widened toward and meets, or almost meets, its fellow of the opposite side.

The distinguishing characters of *florida*, described, as has been stated above, from the female only, were originally given as "front immaculate above, the stripes of the thorax being broader, not well terminated," as compared with *luteipennis*. In 1905, I wrote: "The two Mexican females [from Guadalajara and Jalapa] before me have the frons immaculate above and are evidently the *Aeschna florida* of Hagen, although I have not seen the type; they differ in this respect only from the Brazilian females. All the males have a black T-spot on the frons above, although its width varies even in the two Mexican males." As a comment on this statement, I am unable to say whether I did or did not compare the sternum of the second abdominal segment of all the females studied in 1905; the material has long since been scattered and is not available for re-examination.

Ris's (1918) account of Mexican and Costa Rican examples is as follows: "Mexico: Der Stirnfleck ist klein bei den ♂, sehr klein bei dem ♀ von Cuernavaca, fehlt ganz den ♀ von Ocotlan, gut ausgebildet bei dem ♀ von Misantla. Thoraxstreifen breit, licht bis dunkel rotbraun. Bei dem ♂ von Infernillo der Stirmfleck sehr gross; die dunkeln Thoraxstreifen breit und tief samtig dunkel rotbraun."

All the males and all the present females of *luteipennis*, from all countries, which I have seen, possess a larger or smaller black T-spot on the frons, so that no correlation between the two sexes appears to exist in this respect, and the presence, size or absence of the T-spot is not of taxonomic value. The differentials of *florida* would, therefore, seem to be the structural ones given above.

[5]All dimensions of the stigma in this paper are of its costal edge.

The type of *florida*, whether holotype or two or more cotypes, is Deppe's female or females and may be in the Berlin Museum, as suggested above. Under all the present circumstances, it does not seem advisable to designate an allotype or neotype.

The present material which I refer to *luteipennis florida* is Mexico: Las Adjuntas (Munic. Villa de Santiago), Nuevo Leon June 22, 1938, Harry Hoogstraal, 1 ♂. Chapala, Jalisco, August 30, 1906, P. P. Calvert, 4 ♂. Cuernavaca, Morelos, June, O. W. Barrett, 1 ♂.

Costa Rica: Peralta, 1055 feet, August 9, 1909, 1 ♀. Juan Viñas, laguna, 3300 feet, March 19, 1910, 1 ♂, May 4, 1910, 1 ♀ ovipositing; 3400 feet, June 23 and 24, 1909, 2 ♂, (1 of them by W. Schaus & J. Barnes) 1 ♀. Paraiso, 4380 feet, October 11, 1909, 1 ♀ ovipositing. Las Concavas, 4550? feet, October 12, 1914, C. H. Lankester, 1 ♂, 1 ♀. Cartago and immediate vicinity, 4700 feet, May 15, June 17 and 18, August 28, November 2, all 1909, 1 ♂ each day. Laguna Ochomogo, 5000 feet, September 25, 1909, 2 ♂. Alajuela, 3100 feet, September 15, 1909, 1 ♀. Collector P. P. Calvert, except where otherwise stated.

Panama: Chiriqui, 4100 feet, June 23, 1937, C. B. Worth, 1 ♀. El Volcan Chiriqui, February 29, 1936, W. J. Gertsch, 1 ♂, Amer. Mus. Nat. Hist. New York.

Except the male from El Volcan Chiriqui, all the above material is in the collection of P. P. Calvert, Acad. Nat. Sci. Phila.

Dimensions of the above Mexican male specimens: abdomen (excl. apps.) 53–57; sup. apps. 5.24–6.25; hind wing 45–49; stigma of front wing 3.76–4.17 mm.

Dimensions of the above Costa Rican specimens: abdomen (excl. apps.) ♂ 55–57, ♀ 59–62.5; sup. apps. ♂ 5.32–5.73, ♀ 1.06–1.22; hind wing ♂ 47–49, ♀ 48–50; stigma of front wing ♂ 3.60–4.34, ♀ 3.68–4.34 mm.

3. Aeshna (Coryphaeschna) luteipennis peninsularis new subspecies
Aeschna luteipennis Calvert 1895, p. 503, pl. xv, figs. 27–28.

The males have the superior appendages as shown in the accompanying figures 8 and 9. The female is unknown.

Holotype male: Los Parres, October 7, 1923, Jesse H. Williamson, ex coll. E. B. Williamson. Paratype: Mesa Verde, October, 1893, G. Eisen, 1 ♂. Both from Baja California and in Acad. Nat. Sci. Phila.

Dimensions ♂: abdomen (excl. apps.) 56, 58.5; sup. apps. 6.54; hind wing 45, 47; stigma of front wing 3.60, 4.09 mm.

There remains the Colombian material quoted above from Ris (1918) and from Navás (1935) and of which Ris says: "Alle Expl. von Rio Aguacatal und S. Antonio übereinstimmend mit ganz grünen Thorax bis auf feine rotbraune Linien in der Schulternaht und hintern Seitennaht und etwas breitere (beide Seiten zusammen nicht ganz 1 mm.) an der Mediannaht und vorne in der Furche am Flügelsinus (die ♀ sind in den Farben ordentlich, die ♂ ausgezeichnet erhalten). Stirnflecken der ♂ gross, der ♀ ziemlich gross. Am Appendix superior der ♂ der ventrale Fortsatz am Ende etwas weiter lateralwärts vorspringend als bei den ♂ von Mexico und Costarica."

I have seen no material from Colombia and hence can say nothing of the character of the male appendages.

There is a wide gap of 2500 miles (4000 km.) in the present known distribution of *luteipennis* from the localities quoted from Colombia to the State of Espirito Santo in Brazil. This is nearly half that between the two extreme points from which the species has been reported. None of the lists of collections from the Amazons or its tributaries include *luteipennis*, although *Ae.* (*C.*) *virens* and *adnexa* have been taken along the great river.

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AESHNA RUFIPENNIS, A NEW DRAGONFLY FROM PERU

(Aeshnidae: Odonata)

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Early this year the writer received from the collector, Pedro Paprzycki four male Aeshnas of a form which closely resembled *Aeshna luteipennis* Burm. var. *florida* Hagen, but which differed from the latter in minor genitalic characters. The specimens were labeled Satipo, Peru, and were collected from November 26 to December 27, 1940. Because Doctor P. P. Calvert wishes to include them in a review of South American Aeshnas we present the following description:

Aeshna rufipennis n. sp.

(Figs. 1–9)

Holotype, male: Hind wing 46 mm. Abd. including appendages 60 mm. Appendages 7 mm. long.

Labium with submentum yellowish green, the mentum and lateral lobes (palps) grayish blue shading into orange red on their terminal third. (See figs. 1 and 2 for pattern.) Base of mandible brown with a rectangular pale greenish yellow spot on the basal half of its outer surface. Face pale blue with the anteclypeus slightly greenish, the labrum narrowly edged below with brown, a very fine brown line separating clypeus and frons, the outer end of the T-spot covering the upper half of the vertical surface of the frons. Sides and top of frons greenish except for the large equilateral V-shaped T-spot. (Fig. 2.) Vertex black with a minute pale spot on each outer anterior surface. Antennae black. Eyes brown in holotype (but pale grayish green in lower surface in specimen No. 3 taken Dec. 12, 1940, with darker green above). Occipital triangle black enclosing a minute pale spot. Rear of head black except for a lateral yellowish green spot on each side at the sinuation of the posterior edge of the eye. (In *luteipennis* is a blue spot above occipital foramen. In our dried specimens the heads cover this area so its color is undetermined.)

Prothorax dark green or black (in holotype covered by head and fore-legs) on sides and dorsum except edged behind with narrow band of greenish white.

Pterothorax yellowish green with a triangular middorsal black stripe half as wide below as width of thorax, but the enclosed middorsal carina narrowly edged with green on its lower or vertical half. Antealar sinus with horizontal and vertical surfaces green and its carinae black.

A broad black antehumeral stripe one-third as wide as the mesepisternum. This widens at its top to cover a narrow triangular area in the upper anterior angle of the mesepimeron, below it covers the mesinfraepisternum except for a green spot in the lower posterior angle. On the latter sclerite the humeral stripe tends to become rusty brown. The metinfraepisternum is similarly colored. The lower end of the mesepimerum is enclosed in a rounded border of black. The side of the thorax green with a broad stripe on the second lateral suture (metapleural) of same width and composition of parts as that on the humeral (mesopleural) suture. This stripe widens below to cover the metaspiracle. Both humeral and metapleural stripes are continuous with the blackish brown of the ventral surface which on the metepimeron covers the metepimeral keel.

All coxae brown. Legs black except anterior femora blue on posterior surface. Wings hyaline with very slight tinges of rusty reddish color. (In paratype of Nov. 26, 1940, this rusty color of the wing membrane is more striking.) Pterostigmas brownish black. Anal membrane dark brown.

Abdomen. Seg. 1 green with dorsum black and anterior and posterior edges of side narrowly black except a narrow blue-green "D" spot on apex of dorsum. Sternum brown. (We will follow Walker's terms for abdominal pale spots. "Genus Aeshna," 1912, fig. 1, p. 9.)

Seg. 2 green by the enlargement of all pale spots, except for three large black lateral spots, the two upper of which are rectangular while the lower spot is an equilateral triangle whose anterior basal angle lies under the free posterior apex of the auricle. The upper free half of auricle green, its lower half black. The lower inturned pleural areas green. Sternal parts brown and black.

Seg. 3 black with a narrow middorsal green stripe confluent with the pairs of MD and PD, all of which spots are small and triangular. AL full size, covering the lower half of side but dusky in the lower half (artefact?). Inturned pleural edges brown. Sternum black. Segs. 4–6 black and alike in the two pairs of minute triangular green spots, MD and PD of Walker's terms. PD increases in size from 3 to 6; MD decreases in size from 3–6 and is absent on segs. 7–10. Seg. 7 with PD only. Segs. 8–10 and appendages black. All pleurites edged with brown below. Sternites black except the pair of flaps covering the sexual opening on seg. 9 which are broadly edged with pale.

Described from the holotype male, specimen No. 2, collected December 27, 1940, at Satipo, Peru, by Pedro Paprzycki and now in the writer's collection. The paratype material consists

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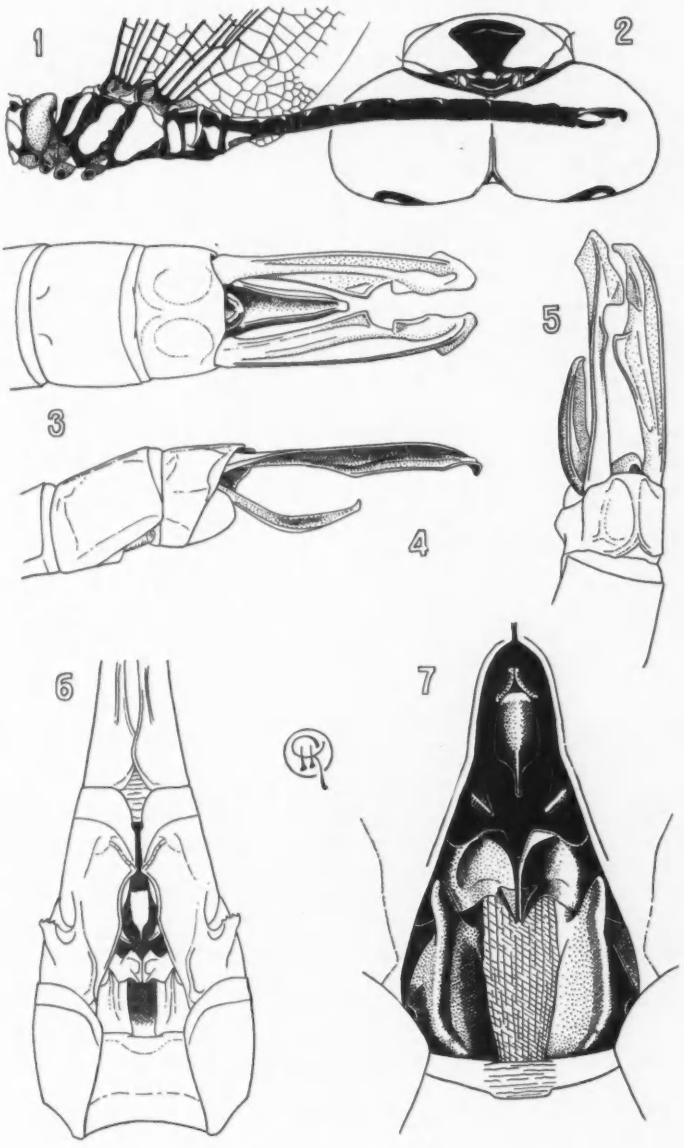
EXPLANATION OF FIGURES

Figs. 1–7. *Aeshna rufipennis*, n. sp., male. 1. Color pattern. 2. Color of vertex. 3–5. Apical abdominal appendages. 6. Ventral side of abdominal segments 1 and 2. 7. Sexual organs of ventral side of abdominal segment 2. Figs. 1–5 are drawn from the holotype male. Figs. 6 and 7 are from male paratype, collected Dec. 12, 1940, at Satipo, Peru.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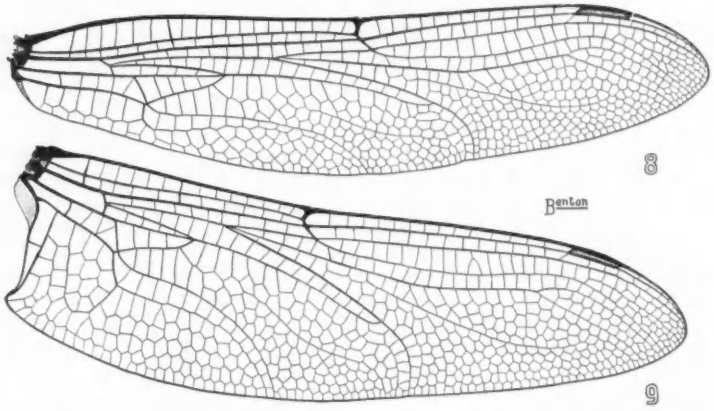
of three other males as follows: Specimen No. 1, Satipo, Peru, Nov. 26, 1940. Wings extensively tinged with rusty brown. Abd. including app. 59 mm. long, app. 7.5 mm.; hind wing 47 mm. Given to the Williamson Collection, Zoological Museum, Ann Arbor, Mich. Specimen No. 3, Satipo, Peru, Dec. 12, 1940. Wings and second segment figured. Wings wholly hyaline. Abd. incl. app. 60 mm., app. 7.5 mm.; hwg. 47 mm. In Kennedy Collection. Specimen No. 4, Satipo, Peru. Abd. incl. app. 54 mm., app. 5.8 mm., hwg. 43 mm. In Calvert Collection, Phila. Acad. Nat. Sci.



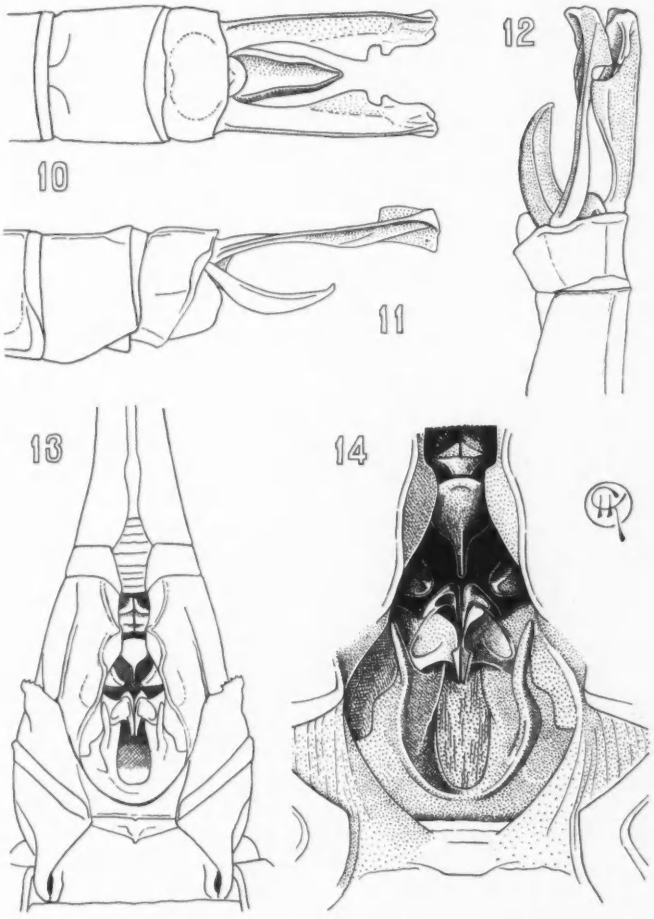
Figs. 8 and 9. *Aeshna rufipennis*, n. sp., male. The right wings of the male collected Nov. 26, 1940, and now deposited in the Williamson Collection at the Zoological Museum, University of Michigan.

Rufipennis = red wing, paralleling *luteipennis* which means yellow wing. In both species the wings are at first hyaline then become rusty brown with age.

The color pattern is so similar to that of *luteipennis* Burm. that it is well within the possible variability of the color pattern of the latter. Even such details as the two pale specks on the vertex, the pale spot on the back of the head at the sinuosity of the hind border of the eye and the pale green posterior surface of the fore femur are present. This identity of color pattern with that of *luteipennis* suggests that we are dealing with a variety of *luteipennis*.

The differences between *rufipennis* and *luteipennis* are structural. (1) In *luteipennis* the appendages of the male, in

side view, are squarely truncate (figs. 10 and 11). In *rufipennis* in the same view they taper to a point the apex of which is turned down (fig. 4, also 5). In the copulatory apparatus on



Figs. 10–14. *Aeshna luteipennis florida* Hagen, male. 10–12. Apical abdominal appendages. 13. Ventral side of abdominal segments 1 and 2. 14. Sexual organs of ventral side of abdominal segment 2. Figs 10–14 are from a male collected by P. P. Calvert, Cartago, Costa Rica, June 17, 1909, and now in the Kennedy Collection.

the second abdominal segment are slight differences in *rufipennis* from the same parts in *luteipennis*. (2) In shape the two posteriorly directed spines of the anterior sternal plate are similar. In each species they are blunt and broadly bladed on the ental side. In *rufipennis* this shape is evident (fig. 7), but in *luteipennis* (fig. 14) the blade is hidden because of its more vertical position. This difference, however, might be due to the amount of closure of the parts of seg. 2 in relation to the extrusion of the penis. In this instance we do not believe so, as the penis is more retracted in *rufipennis* where these spines are laid almost on their ectal side. (3) The pointed anterior tips of the anterior hamules have broader bases in *rufipennis*, and the inner posterior folds of the first hamules are concealed under the posterior ends of the outer posterior folds (fig. 7). In *luteipennis* the inner posterior folds of the first hamules are conspicuous (fig. 14) in their projection beyond the outer or ventral folds. (4) In *rufipennis* (fig. 7) the second or posterior hamules are more pointed than are those of *luteipennis* (fig. 14).

The two figures, 7 and 14, are camera lucida sketches at the same magnification. The general differences of the fossa walls (ventral edges of the pleurite of seg. 2) may be due to the difference in the positions of the penes. In fig. 7 (*rufipennis*) the penis is deeply retracted. In fig. 14 (*luteipennis*) it is nearer the surface, hence in the latter the two pleural flaps at the sides of the penis sheath are thrust outwards into a nearly horizontal position. After a study of shapes of the fossa walls in *Anax junius* from various localities (Kennedy, 1934, Ann. Ent. Soc. Amer. 27: 353, figs. 17 and 18) the writer would hesitate to term differences in fossa walls to be of specific rank when no greater than these. In *Anax junius* fossa walls are remarkably variable.

The auricle of seg. 2 in both *rufipennis* and *luteipennis* has four retrose teeth, minute and needle-sharp.

For the previous comparisons we have examined two males of *luteipennis* collected by Calvert in Costa Rica, var. *florida* Hagen, and now in our collection; also one male from São Paulo, Brazil, from the Cowley collection borrowed through Doctor Calvert. The latter is var. *luteipennis* Burm.

We have had the privilege of studying Doctor Calvert's manuscript (published in this issue of the Annals) while studying our material. His fig. 9 of a male *luteipennis* from Baja California is nearest in appearance to our fig. 5, but a comparison

of the apex of the left superior appendage in our fig. 5 with that part in his fig. 9 will show striking differences. One is acute, the other is truncate.

Coryphaeschna. The forked Rs and the long quadrangle with curved posterior side, the single row of cells between Cu_1 and Cu_2 are characters of *Coryphaeschna ingens* (Ramb.). Thus *rufipennis* can be classified into the Williamson genus Coryphaeschna with *ingens* (Rambur), *virens* (Rambur), *adnexa* (Hagen) and *luteipennis*. We are leaving it in Aeshna because Doctor Calvert is at present completing a general study of South American Aeshnines and will make a decision as to its position.

THE COMPARATIVE PHYSIOLOGY OF RESPIRATORY MECHANISMS, by AUGUST KROGH. Pages V+172, 84 figs. 1941. 6 x 9 inches. Published by the UNIVERSITY OF PENNSYLVANIA PRESS, 3622 Locust Street, Philadelphia, Pa. Price, cloth, $3.00.

This precise comparative review of the various types of respiratory mechanism found in the animal kingdom is the lecture course on the subject given by Professor August Krogh under the William J. Cooper Foundation at Swarthmore College in 1939. Professor Krogh of the Laboratory of Zoophysiology of Copenhagen University, is a very high authority in comparative physiology. To these lectures we call the attention of entomologists who are interested in the broader problems of insect respiration and with the problems of respiratory poisons in particular.

The subject matter is treated under the following headings: I. The Call for Oxygen; II. The Access to Oxygen; III. Forces Acting in the Transport of Oxygen (and CO_2) Through Living Tissues; IV. Respiration in Water; V. Emergency Respiration. The Transition to Air Breathing; VI. Respiration in Air; VII. Respiratory Functions of Blood; VIII. Tracheal Respiration; IX. Concluding Remarks.

In the introduction the author states, "What I shall endeavor to illustrate is: (1) the enormous difference in the 'call for oxygen' shown by different organisms and under varying conditions; (2) the variations in the accessibility of oxygen in the different habitats occupied by animals; and the main theme will be (3) the adaptation of respiratory mechanisms to these widely varying conditions." Arthropod respiration and particularly insect respiration is treated, and usually generously, under each comparative problem presented. The first table (p. 3) compares "the call for oxygen" in Paramaecium, Mussel, Crayfish, Butterfly (resting, flying), Carp, Pike, Mouse and Man. Then are discussed the influence of size, of organization, of temperature, of activity and of adverse conditions. Each discussion is thoroughly documented and at the end of the volume is a bibliography of nineteen pages. It includes titles in each case. In the passage on insect respiration Wigglesworth and Krogh himself are extensively quoted. Professor Krogh rates as one of the world's greatest physiologists. Before the present unpleasantness abroad any physiologist who could refer casually to having studied in Krogh's Laboratory of Zoophysiology at Copenhagen University received immediate attention from those of lesser opportunity.

We admire the volume because it is unusually well written. The English is brilliantly simple and clear. The last chapter is as carefully written as is the first. We would enjoy studying under such a man ourselves.—C. H. K.

THE GENERIC NAMES OF MEIGEN 1800 AND THEIR PROPER APPLICATION

(Diptera)

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Since the republication of a portion of Meigen's "Nouvelle classification des mouches a deux ailes (Diptera L.)" by Hendel (1908), in which he placed in synonymy many of the names proposed by Meigen in 1903, there has been divided opinion as to the names to be used for the genera involved. While many discussions of this problem have been published, it is thought advisable at the beginning of this paper to present a consideration of the arguments that have been offered as justification for the rejection of the names of Meigen 1800.

1. That the names are *nomina nuda*. This has been the contention of a number of dipterists, based on the fact that none of the genera, as originally proposed, contained named species. These workers fail to realize that the names are binary and are therefore valid under the Rules. In Opinion 46 of Opinions Rendered by the International Commission on Zoological Nomenclature (Smithsonian Institution, Washington, Publication 2060, February, 1912; see page 105) it is stated:

> "Article 2 provides that the designation for subgenera and all higher groups is uninominal, and Article 25 provides that a name must be published and accompanied by an indication, or a definition, or a description, and further, that the author must have applied the principles of binary nomenclature."
>
> "If an author clearly shows that the name he proposed is to be applied in the generic sense, and if this name is uninominal, the name in question becomes available under the Code, for his paper shows that he applied the principles of binary nomenclature, although he may have failed to name the species."

2. That the names are valid but date from the time of the first inclusion of species. This contention is erroneous, since a genus dates from the time that it is validly proposed and not at any later date. This is definitely stated in Opinion 54. A generic name may represent a *genus dubium* until a species is included in it, but this does not alter the date of its validity.

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[1]In preparing this paper the writer used a photostatic copy of the entire original paper of Meigen published in 1800, prepared from a copy in the Academy of Natural Sciences of Philadelphia.

3. That the descriptions are unrecognizable This is true in a number of instances, but the same may be said of the descriptions of many accepted genera, both with and without originally included species. Any genus for which no type has been fixed requires further clarification, and it frequently is necessary to change a well established concept of a genus following the designation of its type or a critical study of its originally fixed type. Types have been selected for most of Meigen's first genera and recognition of the genera must be based upon a study of these species. Opinion 46, which will be discussed later, provides the valid procedure for the designation of types of genera such as these.

4. That the stability of nomenclature will be seriously upset by the overthrow of many well established names. This also is true, but we cannot hope to have stability as long as some workers respect the Rules and others do not. If all entomologists agreed not to use the names of Meigen 1800 we would have stability, but we cannot expect to attain unanimous disregard of the Rules. It is barely possible that the Commission would be willing to place some of the names subsequent to 1800 on the Official List of Generic Names, thereby invalidating the prior names, but in the thirty years since the names of 1800 were declared to be available by the Commission, such a request has not been made, to the knowledge of the writer. It does not seem reasonable to expect that the Commission would be willing to invalidate the 1800 names at this late date, especially since a number of workers and important publications have adopted them. W. P. Curtis (1933) has ably discussed this question of stability, and his paper should be read by anyone interested in this phase of the question.

5. Other arguments. It has been suggested that Meigen did not expect the names to be considered as having nomenclatorial standing since in the Introduction by Baumhauer to the 1800 paper it is stated " . . pour ne pas anticiper ce dernier, ne contiendroit absolutement que les genres." However, if such was the intention, it has no bearing on the validity of the names It has also been suggested that the 1800 paper was not actually published and that the J. G. Meigen of 1800 was not the same as the J. W. Meigen of 1803. Opinion 28 definitely establishes that it was published, and it is obvious that Meigen's middle name would be spelled Guillaume in the French publication and Wilhelm in the German.

The principal purpose of the present paper is to show what the types of the genera of Meigen 1800 are when the rules are strictly applied. It will be seen that when this is done the results are, in some instances, at variance with the present use of the names of 1800. For the sake of future stability it is the writer's opinion that the Rules should be followed strictly. While it is possible, in cases of rather obvious misapplications of names, that the Rules may be suspended by plenary power of the Commission, it is scarcely probable that they will be, and it would seem best to accept the genotype designations as they stand. In arriving at the designations contained in this paper the writer

found two Opinions (46 and 65) of the International Commission particularly pertinent, and a brief discussion of these seems desirable.

Opinion 46. This Opinion lays down very definite rules for the designation of types for genera which contained no named species when originally described, and recognizes five categories of such names. The Names of Meigen 1800 all fall into categories 3 and 4, while the 22 similarly proposed names of Meigen 1803 all fall into category 5. In genera of the third category, "an author may have described a genus, clearly giving generic characters, but failing to give either a separate description or figure (illustration) of the spceies he studied, while from the original publication it is clear that he based the genus on a single species, which he did not mention by name," and "if any author claims to recognize the species which an author took as basis for a genus of the third category, his recognition is assumed to be correct until proved to be incorrect." All the genera of Meigen 1800 said to contain "1 espece" fall into this category, an example being *Calirrhoe*. When Hendel listed a single species in connection with an 1800 name of the third category it automatically became the type. A genus described by an author without included species belongs to the fourth category if "it is clear that he based his genus on a definite number of species (1, 2, 3, etc.), which he did not mention by name." All the Meigen 1800 genera said to contain more than one species fall into this category. In these genera "any one of the species referred to is available as type" but it is necessary to designate a type. It is not sufficient to include a species in the genus. A genus of the fifth category "contains all of the species of the world which would come under the generic description as originally published" and "the first species published as member or members of the genus are the only species available as type." Meigen, in 1804, included a single species in several of his binary genera of 1803, and these automatically became the types of these genera, which are monobasic. Opinion 46 also states that "In genera published without mention, by name, of any species, no species is available as genotype unless it can be recognized from the original generic publication." This, of course, provides abundant opportunity for instability, since it can nearly always be said that the genotype cannot be recognized from the original description. Very few of the early generic descriptions were applicable to one genus alone. The remedy for this instability would seem to be to accept the type

designation except in the rare cases where there is incontrovertible proof that the designation is erroneous.

Opinion 65. This Opinion deals with the question of misidentified genotypes. It states, "If an author designates a certain species as genotype, it is to be assumed that his determination of the species is correct; if a case presents itself in which it appears that an author has based his genus upon certain definite specimens rather than upon a species, it would be well to submit the case, with full details, to the Commission." The monobasic genera *Siphona*, *Ceratopogon*, and *Atractocera* have all been assumed to be based upon species other than those named, but there is no indication in the original descriptions of these genera that the descriptions were based upon certain definite specimens, so the stated types could not be overruled by the Commission.

It is rather generally considered that the names of 1803 were proposed by Meigen because he did not consider his earlier names to be etymologically correct or acceptable. This probably is true, but since the 1803 paper says nothing to this effect and contains no reference whatsoever to the 1800 paper, Article 30 II f concerning "a generic name —— proposed as a substitute for another generic name" does not apply. The type designated for one genus does not become, *ipso facto*, the type of the other.

The Genera of Meigen 1800

In the following list, all the generic names proposed for the first time by Meigen in 1800 are given in alphabetical order. Each name is followed by its original page citation in parentheses, the type, the designator of the type, and the date and page of its designation. The complete references, to which these brief, parenthetical citations refer, may be found in the bibliography at the end of the paper. Under each genus are given the earlier synonyms or prior equivalent names (those of Meigen 1803 or earlier, or the next available name after 1803), but not the many later synonyms. The type and method or place of designation are given in the same way for these generic names. The names in bold face have priority and are therefore valid; the names in italics are synonyms or homonyms. Any one wishing to look up a particular generic name associated with those of Meigen 1800 may do so by consulting the alphabetical list which follows this section of the paper.

As a reult of the present study on genotypes, the following new synonyms are here proposed for the first time.

(*Petaurista* Meigen, 1800, preoc.) = *Melusina* Meigen, 1800.
(*Trichocera* Meigen, 1803) = *Melusina* Meigen, 1800.
(*Clytocerus* Eaton, 1904) = *Phalaenula* Meigen, 1800.
(*Molophilus* Curtis, 1833) = *Erioptera* Meigen, 1803.
(*Tritonia* Meigen, 1800, preoc.) = *Temnostoma* Lepeletier and Serville, 1828.
(*Apemon* Johannsen, 1909) = *Platyura* Meigen, 1803.

All Generic Names Proposed for the First Time by Meigen in 1800

Amasia Meigen (1800, p. 20). *Genus dubium*, for which no type has been selected.

Hendel (1908, p. 50) considered *Penthetria* Meigen (1803, p. 264) to be a synonym, but designated no type, and this synonymy has not been accepted.

Amphinome Meigen (1800, p. 15). Type, *Tipula tripunctata* F. (Coquillett, 1910, p. 505). Preoccupied by *Amphinome* Bruguiere, 1792.

=**Limonia** Meigen (1803, p. 262). Type, *Tipula tripunctata* F. (Westwood, 1840, p. 129).

Antiopa Meigen (1800, p. 32). Type, *Musca bicincta* L. (Coquillett, 1910, p. 508).

Syn., *Chrysotoxum* Meigen (1803, p. 275). Type, (*Mulio bicinctus* (F.)) = *Musca bicincta* L. (Latreille, 1810, p. 443).

Apivora Meigen (1800, p. 37). Type, *Musca pellucens* L. (Coquillett, 1910, p. 508).

Syn., *Pterocera* Meigen (1803, p. 275). Type, *Musca pellucens* L. (Coquillett, 1910, p. 597). Preoccupied by *Pterocera* Lamarck, 1799.

=**Volucella** Geoffroy (1762, p. 540). Type, *Musca pellucens* L. (Curtis, 1833, p. 452).

Atalanta Meigen (1800, p. 31). Type, *Clinocera nigra* Mg. (Coquillett, 1910, p. 511).

Syn., *Clinocera* Meigen (1803, p. 271). Type, *Clinocera nigra* Mg. (Meigen 1804, p. 292).

Calirrhoe Meigen (1800, p. 39). Type, *Stomoxys siberita* F. (Hendel, 1908, p. 68).

Syn., *Prosena* Lepeletier and Serville (1828, p. 500). Type, *Stomoxys siberita* F. (Original designation.)

Chrysogaster Meigen (1800, p. 32; 1803, p. 274). Type, *Eristalis solstitialis* Fall. (Zetterstedt, 1843, p. 816).

Chrysops Meigen (1800, p. 23; 1803, p. 267). Type, (*Chrysops caecutiens* F.) = *Tabanus caecutiens* L. (Latreille, 1810, p. 443).

Chrysozona Meigen (1800, p. 23). Type, *Tabanus pluvialis* L. (Coquillett, 1910, p. 524).

Syn., *Haematopota* Meigen (1803, p. 267). Type, *Tabanus pluvialis* F.) = *Tabanus pluvialis* L. (Monobasic.)

Clinxia Meigen (1800, p. 35). Type, *Musca lappona* L. (Coquillett, 1910, p. 524).

Syn., *Sericomyia* Meigen (1803, p. 274). Type, *Syrphus lapponum* (F.)) = *Musca lappona* L. (Latreille, 1810, p. 443).

Cleona Meigen (1800, p. 30). Type, *Callomyia elegans* Mg. (Coquillett, 1910, p. 525).

Syn., *Callomyia* Meigen (1804, p. 311). Type, *Callomyia elegans* Mg. (Monobasic.)

Clythia Meigen (1800, p. 30). Type, *Platypeza fasciata* Mg. (Coquillett, 1910, p. 525).

Syn., *Platypeza* Meigen (1803, p. 272). Type, *Platypeza fasciata* Mg. (Blanchard, 1849, pl. 170, fig. 7).

Coryneta Meigen (1800, p. 27). Type, *Tachydromia connexa* Mg. (Coquillett, 1910, p. 528).

Syn., *Tachydromia* Meigen (1803, p. 269). Type, *Musca cimicoides* F., as synonym of *Tachydromia arrogans* L. (Curtis, 1833, p. 477).

Coquillett (1903, p. 258) designated *Tachydromia connexa* Mg., which is an invalid designation since the name *connexa* was not originally included.

Crocuta Meigen (1800, p. 39). Type, *Musca geniculata* Deg. (Coquillett, 1910, p. 528).

Syn., *Bucentes* Latreille (1809, p. 339). Type, "*B. cinereus*; *Musca geniculata* De Geer" (monobasic); *Musca geniculata* Deg. (Latreille, 1810, p. 444).

Hendel (1908, pp. 66 and 68) placed *Siphona* Meigen (1803, p. 281) as a synonym of *Crocuta* on the assumption that Meigen misidentified the genotype of *Siphona*, (*Stomoxys irritans* (F.)) = *Conops irritans* L. However, this cannot be assumed, and, as Speiser (1905, p. 461) has pointed out, *Haematobia* Lep. & Serv. falls as a synonym of *Siphona* Mg.

Cyanea Meigen (1800, p. 40). *Genus dubium*, for which no type has been designated.

Cypsela Meigen (1800, p. 31). Type, (*Musca subsultans* F.) = *Musca subsultans* L. (Coquillett, 1910, p. 530).

Syn., *Borborus* Meigen (1803, p. 276). Type, *Musca subsultans* L. (Curtis, 1833, p. 469).

The identity of this genus is in considerable doubt since it is claimed that *Musca subsultans* L. has been misidentified and probably belongs in the genus *Hypocera* of the family Phoridae. If this is true, *Cypsela* Mg. would replace *Hypocera* Lioy and *Cypsela* and *Borborus* of authors, not Meigen, would be replaced by *Sphaerocera* Latreille (1804, p. 197), type *Musca curvipes* Latr. (Latreille, 1805, p. 394). Since *Musca subsultans* is not recognized with certainty, it would seem best to consider the true *Cypsela* and *Borborus* to be *genera dubia*, and to use the name *Sphaerocera* for the genus containing *Musca curvipes* Latr.

Dionaea Meigen (1800, p. 24). Type, *Empis platyptera* Panz. (Coquillett, 1910, p. 534).

Syn., *Platyptera* Meigen (1803, p. 269). Type, *Empis platyptera* Panz. (Absolute tautonymy.)

Dorilas Meigen (1800, p. 31). Type, *Pipunculus campestris* Latr. (Coquillett, 1910, p. 535).

Syn., *Pipunculus* Latreille (1802, p. 463). Type, *Pipunculus campestris* Latr. (Monobasic.)

Syn., *Microcera* Meigen (1803, p. 273). Type, *Pipunculus campestris* Latr. (Coquillett, 1910, p. 569).

Echinodes Meigen (1800, p. 38). *Genus dubium*, for which no type has been designated.

Bezzi, as reported by Hendel (1908, p. 68), suggested that this might be the same as *Eriothrix* Meigen (1803, p. 279), but this suggested synonymy has not been accepted.

Erinna Meigen (1800, p. 21). Type, *Nemotelus cinctus* Deg. (Coquillett, 1910, p. 539).

Syn., *Xylophagus* Meigen (1803, p. 266). Type, *Nemotelus cinctus* Deg. (Monobasic.)

Eulalia Meigen (1800, p. 21). Type, *Musca hydroleon* L. (Coquillett, 1910, p. 541).

Syn., *Odontomyia* Meigen (1803, p. 265). Type, *Musca hydroleon* L. (= *Stratiomys hydroleon* (F.)) (Westwood, 1840, p. 130).

Euphrosyne Meigen (1800, p. 16). Types, *Macrocera lutea* Mg. (Coquillett, 1910, p. 542).

Syn., *Macrocera* Meigen (1803, p. 261). Type, (*Macrocera lutea* Panz.) = *Macrocera lutea* Mg. (Curtis, 1837, p. 637).

Euribia Meigen (1800, p. 36). Type, *Musca artemisiae* F. (Coquillett, 1910, p. 542).

Syn., *Trypeta* Meigen, (1803, p. 277). Type, *Musca artemisiae* F. (Coquillett, 1910, p. 618).

Flabellifera Meigen (1800, p. 13). Type, *Tipula atrata* L. (Coquillett, 1910, p. 545).

Syn., *Ctenophora* Meigen (1803, p. 263). Type, *Ctenophora atrata* (F.) = *Tipula atrata* F.) = *Tipula atrata* L. (Latreille, 1810, p. 442).

Syn., *Tanyptera* Latreille (1804, p. 188). Type, *Tipula atrata* F.) = *Tipula atrata* L. (Monobasic.)

The generic name *Phoroctenia* Coquillett (1910, p. 589) was proposed with *Ctenophora augustipennis* Lw. designated as genotype. This is the genus *Ctenophora* of authors, which does not include the genotype designated by Latreille for the genus *Ctenophora* Mg.

Fungivora Meigen (1800, p. 16). Type, *Mycetophila agarici* Olivier) = *Tipula agarici* De Villers (Coquillett, 1910, p. 545).

Syn., *Mycetophila* Meigen (1803, p. 263). Type, *Mycetophila agarici* Mg. = *Tipula agarici* Deg.) = *Tipula agarici* De Villers (Johannsen, 1909, p. 116).

The proper authorship for *Tipula agarici* is somewhat confused, but apparently its first use was by De Villers (1789, p. 393). Here he states that his description is "Ex oper. D. de Geer" and his description contains the exact description given by Degeer (1776, p. 367), for *Tipula agarici seticornis*. Olivier (1811, p. 77) cites the Degeer description, so we can be sure that Olivier and De Villers were both treating the same thing. Meigen credited the species to Degeer when he described *Mycetophila*.

Helea Meigen (1800, p. 18). Type, *Ceratopogon communis* Mg. (Coquillett, 1910, p. 549).

Syn., (?) *Ceratopogon* Meigen (1803, p. 261). Type, *Tipula barbicornis* F.) = *Tipula barbicornis* L. (Monobasic.)

It is believed that *Tipula barbicornis* as recognized by Fabricius is identical with *Ceratopogon communis* Mg., but since it must be assumed that *Tipula barbicornis* L. is the type of *Ceratopogon* Mg., and since this latter species has not been definitely identified, the genus *Ceratopogon* is a *genus dubium*.

Hermione Meigen (1800, p. 22). Type, *Musca hypoleon* L. (Coquillett, 1910, p. 551).

Syn., *Oxycera* Meigen (1803, p. 265). Type, (*Stratiomys trilineata* (F.)) = *Musca trilineata* L. (Curtis, 1833, p. 441).

Iphis Meigen (1800, p. 27). Type, *Musca ungulata* L. (Coquillett, 1910, p. 555).

= **Dolichopus** Latreille (1796, p. 159). Type (*Dolichopus ungulatus* (F.)) = *Musca ungulata* L. (Latreille, 1810, p. 443).

Itonida Meigen (1800, p. 19). Type, *Tipula pini* Deg. (Coquillett, 1910, p. 556).

Syn., *Cecidomyia* Meigen (1803, p. 261). Type, *Tipula pini* Deg. (Monobasic.)

Lampetia Meigen, (1800, p. 34). Type, *Syrphus clavipes* F. (Coquillett, 1910, p. 557).

Syn., *Merodon* Meigen (1803, p. 274). Type, *Syrphus clavipes* F. (= *Syrphus curvipes* Gmel. = *Syrphus curvipes* F. of Meigen). (Westwood, 1840, p. 137).

Although the name *Syrphus clavipes* F. was not originally associated with the genus *Merodon*, there is every reason to believe that *Syrphus curvipes* F. of Meigen (Fabricius described no *S. curvipes*) is equivalent to *Syrphus curvipes* Gmelin, which is a *lapsus* for *Syrphus clavipes* F., two citations for the latter being given under *curvipes*. For this reason, the writer feels justified in accepting Westwood's designation.

Lapria Meigen (1800, p. 25). Type, *Asilus gibbosus* L. (Coquillet, 1910, p. 557, as *Laphria*).

Syn., *Laphria* Meigen (1803, p. 270). Type, *Laphria gibbosa* (F.)) = *Asilus gibbosus* L. (Latreille, 1810, p. 443).

Larvaevora Meigen (1800, p. 38). Type, *Musca grossa* L. (Coquillett, 1910, p. 557).

Syn., *Tachina* Meigen (1803, p. 280). Type, *Musca grossa* L. (= *Musca grossa* F.) (Wachtl., 1894, p. 142).

Liriope Meigen (1800, p. 14). Type, *Tipula contaminata* L. (Coquillett, 1910, p. 562).

Syn., *Ptychoptera* Meigen (1803, p. 262). Type, (*Ptychoptera contaminata* (F.)) = *Tipula contaminata* L. (Latreille, 1810, p. 442).

Lycoria Meigen (1800, p. 17). Type, *Tipula thomae* L. (Coquillett, 1910, p. 563).

Syn., *Sciara* Meigen (1803, p. 263). Type, (*Hirtea thomae* (F.))= *Tipula thomae* L. (Monobasic.)

Melusina Meigen (1800, p. 19). Type, *Tipula regelationis* L. (Hendel 1908, p. 50).

Syn., *Petaurista* Meigen (1800, p. 15). Type, *Tipula hiemalis* Deg. (Coquillett, 1910, p. 587). Preoccupied.

Syn., *Trichocera* Meigen (1803, p. 262). Type, *Tipula hiemalis* Deg. (Monobasic.)

Syn., *Atractocera* Meigen (1803, p. 263). Type, *Tipula regelationis* L. (Monobasic.)

Although Coquillett designated *Simulium ornatum* Mg. as the type of both *Melusina* and *Atractocera*, these designations are not valid nomenclatorially. *Melusina* belongs to category 3 of Opinion 46. Accordingly, the first name associated with it (*Tipula regelationis* L.) becomes the type. *Atractocera* is monobasic, and according to Opinion 65 the species named is to be accepted as its type. The synonymy resulting from a strict adherence to the Rules is not in accord with the zoological facts, since the descriptions of *Melusina* and *Atractocera* fit the genus *Simulium* much more closely than they do *Trichocera*, and Meigen himself later placed the *Tipula regelationis* of his 1803 paper as a synonym of his *Simulium ornatum*. If we follow the Rules, the well known name *Simulium* is retained for an important genus, while a relatively unimportant genus changes from *Trichocera* to *Melusina*. The only alternative to this solution is suspension of the Rules.

Musidora Meigen (1800, p. 30). Type, *Lonchoptera lutea* Panz. (Present designation.)

Syn., *Lonchoptera* Meigen (1803, p. 272). Type, *Lonchoptera lutea* Panz. (Panzer, 1809, CVIII, pp. 20 and 21).

Noeza Meigen (1800, p. 27). Type, *Musca grossipes* L. (Coquillett, 1910, p. 576).

Syn., *Hybos* Meigen (1803, p. 269). Type, *Hybos funebris* Mg. (Meigen, 1804, p. 240).

Omphrale Meigen (1800, p. 29). Type, *Musca senilis* F. (Hendel, 1908, p. 58).

Syn., *Scenopinus* Latreille (1802, p. 463). Type, *Musca fenestralis* L. (Monobasic.)

Syn., *Hypselura* Meigen (1803, p. 273). Type, *Musca senilis* F. (Monobasic.)

Orithea Meigen (1800, p. 15). *Genus dubium*, for which no type has been designated.

Pales Meigen (1800, p. 14). Type, *Tipula dorsalis* F. (Hendel, 1908, p. 46).

Syn., *Nephrotoma* Meigen (1803, p. 262). Type, *Tipula dorsalis* F. (Monobasic.)

Pelopia Meigen (1800, p. 18). Type, *Tipula cincta* F. (Coquillett, 1910, p. 586).

Syn., *Tanypus* Meigen (1803, p. 261). Type, *Chironomus cinctus* (F.)) = *Tipula cincta* F. (Latreille, 1810, p. 442).

Penthesilea Meigen (1800, p. 35). Type, (*Criorrhina ruficauda*) = *Musca ruficauda* Deg. (Bezzi, in Hendel, 1908, p. 67).

Syn., *Criorhina* Meigen (1822, p. 236). Type, *Syrphus asilicus* Fall. (Westwood, 1840, p. 136).

Since *Penthesilea* belongs to category 3 of Opinion 46, the recognition of *Criorhina ruficauda* as the single included species by Bezzi fixes it as the type and replaces the later designation of *Syrphus asilicus* Fall. made by Coquillett (1910, p. 528).

Petaurista Meigen (1800, p. 15). Preoccupied by *Petaurista* Link 1795. = **Melusina** Meigen (q. v.).

Phalaenula Meigen (1800, p. 18). Type, *Trichoptera ocellaris* Mg. (Coquillett, 1910, p. 587).

Syn., *Clytocerus* Eaton (1904, p. 59). Type, (*Pericoma dalii* Eaton) = *Pericoma dalei* Eaton (Enderlein 1935, p. 247).

Since the two species *ocellaris* and *dalei* are accepted as being congeneric, the above synonymy is necessary. *Phalaenula* has been considered to be a synonym of *Psychoda* Latreille (1796, p. 152), which is monobasic, with *Tipula phalaenoides* L. as its type, and Latreille, at the time that he placed *Tipula phalaenoides* in the genus *Psychoda* as its first included species (1802, p. 424), also synonymized *Phalaenula* Mg. with it. However, since *Phalaenula* belongs to category 4 of Opinion 46, it requires definite type designation which was not provided until 1910.

Philia Meigen (1800, p. 20). Type, *Tipula febrilis* L. (Coquillett, 1910, p. 588).

Syn. *Dilophus* Meigen (1803, p. 264). Type, (*Dilophus febrilis* (Mg.)) = *Tipula febrilis* L. (Latreille, 1810, p. 442).

Phryne Meigen (1800, p. 16). Type, *Tipula fuscata* F. (Coquillett, 1910, p. 589).

Syn., *Anisopus* Meigen (1803, p. 264). Type, *Anisopus fuscus* Mg. (Coquillett, 1910, p. 507).

= **Sylvicola** Harris (1776, p. 100). Type, *Sylvicola brevis* Harris (Coquillett, 1910, p. 610).

Polymeda Meigen (1800, p. 14). Type, *Erioptera lutea* Mg. (Coquillett, 1910, p. 593).

Latreille (1802, p. 423) suggested that *Tipula hiemalis* Degeer belonged in *Polymeda*, but queried the association. This action did not constitute type designation. Coquillett (1910, p. 540) designated *Erioptera lutea* Mg. as the type of *Erioptera* Meigen (1803, p. 262), but this type designation is subsequent to that of Blanchard (1849, pl. 163, fig. 3), who designated *Erioptera grisea* Mg. as the type. Curtis (1835, p. 557) designated *Tipula flavescens* L. as the type of *Erioptera*, but *flavescens* was not one of the first species

included in the genus and therefore was not available for type designation. Since *Molophilus brevipennis* Curtis and *Erioptera grisea* Mg. are accepted as being congeneric, *Molophilus* Curtis (1833, p. 444) becomes a synonym of *Erioptera* Mg. (New synonymy.)

Polyxena Meigen (1800, p. 19). Type, *Cordyla fusca* Mg. (Present designation.)

Syn., *Cordyla* Meigen (1803, p. 263). Type, *Cordyla fusca* Mg. (Meigen 1804, p. 93).

Potamida Meigen (1800, p. 22). Type, *Stratiomys ephippium* F. (Hendel. 1908, p. 53).

Syn., *Clitellaria* Meigen (1803, p. 265). Type, *Stratiomys ephippium* F. (Monobasic.)

Rhodogyne Meigen (1800, p. 39). Type, *Musca rotundata* L. (Coquillet, 1910, p. 600).

Syn., *Gymnosoma* Meigen (1803, p. 278). Type, (*Musca rotundata* F.) = *Musca rotundata* L. (Monobasic.)

Salmacia Meigen (1800, p. 38). Type, *Musca capitata* Deg. (Coquillett, 1910, p. 602).

Syn., *Gonia* Meigen (1803, p. 280). Type, *Musca capitata* Deg. (Curtis, 1835, p. 533).

Salpyga Meigen (1800, p. 37). *Genus dubium*, for which no type has been designated.

Scopeuma Meigen (1800, p. 36). Type, *Musca merdaria* F. (Coquillett, 1910, p. 604).

Syn., *Scathophaga* Meigen (1803, p. 277). Type, *Musca merdaria* F. (Monobasic.)

Statinia Meigen (1800, p. 36). Type, *Musca marginata* F. (Hendel, 1924, p. 211).

Syn., *Coremacera* Rondani (1856, p. 106). Type, *Scatophaga marginata*) = *Musca marginata* F. (Original designation.)

The earliest type designation for *Statinia*, as far as the writer can discover, is that by Hendel, the association of the name *Musca marginata* F. with the generic name by Latreille (1802, p. 461) not constituting type designation. Hendel (1908, p. 64) placed *Dictya* Meigen (1803, p. 277) as a synonym of *Statinia*, but designated no genotype and thus synonymy has not been accepted. Hendel (1908, p. 69) considered both *Statinia* and *Dictya* to be synonyms of *Tetanocera* Dumeril 1798. No paper of this date by Dumeril has been discovered, and its existence is doubtful. The earliest valid use of the name *Tetanocera* that has been found is by Latreille (1804, p. 196), with the single included species *Musca graminum* F. Cresson (1920, p. 54) has discussed in detail the nomenclatorial status of *Tetanocera*.

Tendipes Meigen (1800, p. 17). Type, *Tipula plumosa* L. (Coquillett, 1910, p. 612).

Syn., *Chironomus* Meigen (1803, p. 260). Type, (*Chironomus plumosus* (F.) = *Tipula plumosa* F. = *Tipula plumosa* L. (Latreille, 1810, p. 442).

Titania Meigen (1800, p. 35). Type, *Chlorops laeta* Mg. (Coquillett, 1910, p. 615).

Syn., *Chlorops* Meigen (1803, p. 278). Type, *Chlorops laeta* Mg. (Rondani, 1856, p. 125).

Titia Meigen (1800, p. 38). *Genus dubium*, for which no type has been designated.

Trepidaria Meigen (1800, p. 35). Type, *Musca petronella* L. (Coquillett, 1910, p. 615).

Syn., *Calobata* Meigen (1803, p. 276). Type, (*Musca petronella* F.) = *Musca petronella* L. (Monobasic.)

The original description of *Calobata* includes the two names *Musca calobata* Panzer and *Musca petronella* Fabricius. By absolute tautonymy the type would be *Musca calobata*, but the writer has been unable to find any validation of this name. Since the description of the genus *Calobata* is strictly a generic one, applying to both *calobata* and *petronella* and not differentiating between them, the name *calobata* remains a *nomen nudum* and *Musca petronella* F. is the single included species. Westwood (1840, p. 148) designated *Musca petronella* L. as the type of *Calobata*.

Tritonia Meigen (1800, p. 33). Type, *Musca vespiformis* L. (Coquillett, 1910, p. 617). Preoccupied by *Tritonia* Cuvier 1798.

= **Temnostoma** Lepeletier and Serville (1828, p. 518). Type, *Milesia bombylans* F. (Coquillett, 1910, p. 612).

Tubifera Meigen (1800, p. 34). Type, *Musca tenax* L. (Coquillett, 1910, p. 618).

Syn., *Elophilus* Meigen (1803, p. 274). Type, (*Eristalis tenax* (F.) = *Syrphus tenax* (F.)) = *Musca tenax* L. (Latreille, 1810, p. 443).

Syn., *Eristalis* Latreille (1804, p. 194). Type, *Musca tenax* L. (Curtis, 1832, p. 432).

Tylos Meigen (1800, p. 31). Type, (*Musca corrigiolata* F.) = *Musca corrigiolata* L. (Hendel, 1908, p. 60).

Syn., *Micropeza* Meigen (1803, p. 276). Type, (*Musca corrigiolata* F.) = *Musca corrigiolata* L. (Monobasic.)

Zelima Meigen (1800, p. 34). Type, *Musca segnis* L. (Coquillett, 1910, p. 621).

Syn., *Eumeros* Meigen (1803, p. 273). Type, *Musca segnis* L. (= *Syrphus segnis* (F.)) (Lepeletier and Serville, 1828, p. 808).

Syn., *Heliophilus* Meigen (1803, p. 273). Type, *Musca sylvarum* L. (= *Syrphus sylvarum* (F.)). (Coquillett, 1910, p. 550).

Zelmira Meigen (1800, p. 16). Type, *Platyura fasciata* Mg. (Coquillett, 1910, p. 621.)

The genus *Platyura* Meigen (1803, p. 264) has been considered isogenotypic with *Zelmira* Mg., since Zetterstedt (1851, p. 4077) designated *Platyura fasciata* Mg. as the type of *Platyura*. However, Blanchard (1849, pl. 164, fig. 10) designated *Platyura marginata* Mg. as the type of *Platyura* previous to this. Since *marginata* is now placed in the genus *Apemon* Johannsen, (1909, p. 20), this latter genus falls as a synonym of *Platyura*.

Generic Names Associated with the Names of Meigen 1800

The following list is intended to serve as an index to the preceding portion of the paper, listing all the generic names of Diptera mentioned in the preceding portion except those of Meigen 1800. Each name is followed by the name of Meigen 1800 under which it may be found.

Anisopus Mg.—Phryne
Apemon Joh.—Zelmira
Atractocera Mg.—Melusina
Borborus Mg.—Cypsela
Bucentes Latr.—Crocuta
Callomyia Mg.—Cleona
Calobata Mg.—Trepidaria
Cecidomyia Mg.—Itonida
Ceratopogon Mg.—Helea
Chironomus Mg.—Tendipes
Chlorops Mg.—Titania
Chrysotoxum Mg.—Antiopa
Clinocera Mg.—Atalanta
Clitellaria Mg.—Potamida
Clytocerus Eaton—Phalaenula
Cordyla Mg.—Polyxena
Coremacera Rond.—Statinia
Criorhina Mg.—Penthesilea
Ctenophora Mg.—Flabellifera
Dictya Mg.—Statinia
Dilophus Mg.—Philia
Dolichopus Latr.—Iphis
Elophilus Mg.—Tubifera
Erioptera Mg.—Polymeda
Eriothrix Mg.—Echinodes
Eristalis Mg.—Tubifera
Eumeros Mg.—Zelima
Gonia Mg.—Salmacia
Gymnosoma Mg.—Rhodogyne
Haematobia Lep. & Serv.—Crocuta
Haematopota Mg.—Chrysozona
Heliophilus Mg.—Zelima
Hybos Mg.—Noeza
Hypocera Lioy—Cypsela
Hypselura Mg.—Omphrale
Laphria Mg.—Lepria
Limonia Mg.—Amphinome
Lonchoptera Mg.—Musidora
Macrocera Mg.—Euphrosyne
Merodon Mg.—Lampetia
Microcera Mg.—Dorilas
Micropeza Mg.—Tylos
Molophilus Curt.—Polymeda
Mycetophila Mg.—Fungivora
Nephrotoma Mg.—Pales
Odontomyia Mg.—Eulalia
Oxycera Mg.—Hermione
Phoroctenia Coq.—Flabellifera
Pipunculus Latr.—Dorilas
Platypalpus Macq.—Coryneta
Platypeza Mg.—Clythia
Platyptera Mg.—Dionaea
Platyura Mg.—Zelmira
Prosena Lep. & Serv.—Calirrhoe
Psychoda Latr.—Phalaenula Mg.
Pterocera Mg.—Apivora
Ptychoptera Mg.—Liriope
Scathophaga Mg.—Scopeuma
Scenopinus Latr.—Omphrale
Sciara Mg.—Lycoria
Sericomyia Mg.—Cinxia
Siphona Mg.—Crocuta
Sphaerocera Latr.—Cypsela
Sylvicola Harr.—Phryne
Tachnia Mg.—Larvaevora
Tachydromia Mg.—Coryneta
Tanyptera Latr.—Flabellifera
Tanypus Mg.—Pelopia
Temnostoma Lep. & Serv.—Tritonia
Tetanocera Latr.—Statinia
Trichocera Mg.—Melusina
Trypeta Mg.—Euribia
Volucella Geoffr.—Apivora
Xylophagus Mg.—Erinna

Certain Equivalents of the Meigen 1800 Names

The following list is presented to show the treatment of the names applied to groups represented by the Meigen 1800 names by a standard American work, Curran's "The Families and Genera of North American Diptera," and by a standard European work, Lindner's "Die Fliegen der Palaearktischen Region." The former used very few of the Meigen 1800 names, the latter used most of them. The third column shows the usage that appears to be proper by strict adherence to the Rules, and it will be seen that in several instances it differs from the use of the Meigen 1800 names in Lindner.

Curran	*Lindner*	*Present proposals*
Anisopus	Phryne	Silvicola
Apemon	Apemon	Platyura
Borborus	Sphaerocera	Sphaerocera
Callimyia	Calomyia	Cleona
Calobata	Trepidaria	Trepidaria
Cecidomyia		Itonida
Ceratopogon	Helea	Helea
Chironomus	Tendipes	Tendipes
Chlorops	Chlorops	Titania
Chrysotoxum	Chrysotoxum	Antiopa
Clinocera	Atalanta	Atalanta
Cordyla	Polyxena	Polyxena
	Coremacera	Statinia
Criorrhina	Penthesilea	Penthesilea
Ctenophora		Phoroctenia
Dilophus	Dilophus	Philia
Elophilus	Tubifera	Helophilus
Erioptera		Polymeda
Eristalis	Eristalomyia	Tubifera
Euribia	Euribia	Urophora
Gonia		Salmacia
Gymnosoma		Rhodogyne
Haematobia		Siphona
Haematopota	Chrysozona	Chrysozona
Heliophilus	Zelima	Zelima
Hybos	Noeza	Noeza
Laphria	Laphria	Lapria
Lonchoptera	Musidora	Musidora
Macrocera	Macrocera	Euphrosyne
Merodon	Lampetia	Lampetia
Micropeza	Tylus	Tylos
Molophilus		Erioptera
Mycetophila	Fungivora	Fungivora
Nephrotoma		Pales
Odontomyia	Eulalia	Eulalia
Oxycera	Hermione	Hermione
Pipunculus	Dorylas	Dorilas
Platypalpus	Coryneta	Platypalpus
Platypeza	Clythia	Clythia
Platyura	Zelmira	Zelmira
Prosena		Calirrhoe
Ptychoptera		Liriope
Scenopinus	Omphrale	Omphrale
Sciara	Lycoria	Lycoria
Sericomyia	Cinxia	Cinxia
Siphona		Crocuta
Sphaerocera		Cypsela
Tachydromia	Tachista	Coryneta
Tanyptera		Flabellifera
Tanypus	Pelopia	Pelopia
Trichocera	Petaurista	Melusina
Trypeta	Trypeta	Euribia
Xylophagus	Erinna	Erinna

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ANOMALOUS BODY AND LEG SEGMENTATION IN LEPIDOPTERA

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While endeavoring to work out the complete life history of *Polites manataaqua* Harris (Hesperiidae) it was observed that the progeny of one female included an unusually large number of anomalous individuals. These exhibited segmental defects, spiral segmentation, and irregularities of thoracic leg structure. It seems advisable to report these observations in detail because of the paucity of facts regarding phenomena such as spiral segmentation in insects other than *Drosophila*.

There are few cases on record in which either of the parents of anomalous larvae were studied (cf. Learned, 1932, and Cockayne, 1934). In the case here described the female was preserved and carefully examined. Due to the fact that she was fertilized in the field prior to capture the condition of the male is unknown. Also the entire progeny were not secured; however, the specimen was taken very early in the season and was in excellent condition indicating that the duration of life before capture was brief. Accordingly few eggs could have been laid at that time, and the ratio of normal to abnormal offspring based on the number of eggs laid in captivity may be taken as approximately correct. The offspring of numerous other females captured in the same vicinity were also examined but no anomalous individuals were found.

MATERIAL

The number of eggs laid by *Polites manataaqua* varies within rather wide limits. In captivity under optimum conditions an average of fifty are deposited during the lifetime of the female. Frequently all are viable and hatch in from twelve to seventeen days. Under natural conditions the eggs are laid singly over a period of three or four weeks. Under laboratory conditions all the eggs are laid over a period of one week. Each female is confined in a 250 cc. wide-mouth bottle containing several blades of grass and a piece of paper toweling moistened with sugared water. The bottle is covered with a paper cap and placed where it is not exposed to the direct rays of the sun.

From the female in question thirty viable eggs were secured. Of these, sixteen gave rise to abnormal larvae. The incidence of abnormality in this and related species is usually low.

For convenience these abnormalities may be considered under two headings, spiral segmentation and anomalous leg segmentation. Under the former will also be discussed a case of reduction in the number of abdominal segments.

SPIRAL SEGMENTATION

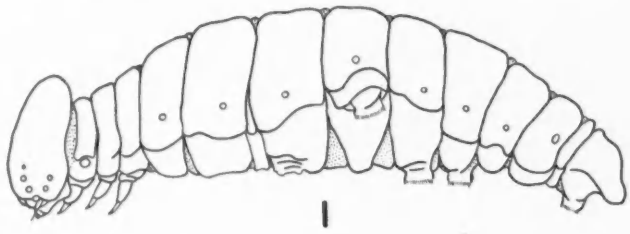
Two larvae exhibited so-called spiral segmentation. Since both were precisely the same in this respect, but one will be described in detail.

This specimen (Table I, larva number 10) also possessed three abnormal thoracic legs. Its general appearance is indicated by figure 1 and the anomalous segmentation fully diagrammed in figures 2–5 which represent the dorsal, left, ventral, and right sides seen consecutively as the specimen was turned in a clockwise direction around its longitudinal axis.

As seen from the dorsal aspect (fig. 2) the animal appears normal. Figure 3 represents the same aspect as figure 1. Here segment five is normal except for a slight pinching in the substigmatal region. At this point is seen an incipient segment representing the beginning of the spiral. Segment six likewise presents a pinched appearance due to the interposition of the additional segment and the initiation of spiral segmentation. The unusual condition of the prolegs of segment six will be discussed below. Segment seven exhibits extreme pinching out in the substigmatal areas. The proleg, which in all other respects is normal, lies at the level of the stigmatal line of the adjacent segments while the spiracle is located close to the region of the para-dorsal line. On the ventral side (figure 4) segment five continues normal. The interposed segment increases to approximately ordinary dimensions. Segment six is usual, but like the preceding one its sutures are oblique to the longitudinal axis of the animal. The spiral condition is most apparent in this ventral view. Segment seven which here represents the end of the spiral peters out. At this point the intersegmental membranes are most extensive. Viewed from the right side the animal appears normal except for the fact that the spiracle on segment seven is rudimentary and not functional. Thus there is a perfect ventral spiral representing two complete turns commencing posterior to segment five and ending anterior to segment eight. Internally the anomaly extended to the muscular, tracheal, and nervous systems. It is thus evident that the defect was not superficial or simply ectodermal in nature.

EXPLANATION OF PLATE I

Fig. 1. View of left side of *Polites manataaqua* larva number 10 showing spiral segmentation, malformed prolegs on segment six, and eccentrically placed proleg on segment seven. 2. Diagrammatic representation of spiral segmentation in larva number 10. Dorsal view. 3. Same. View of left side. 4. Same. Ventral view. 5. Same. View of right side. 6. Ventral view of normal proleg. 7. Ventral view of segment six showing malformed prolegs.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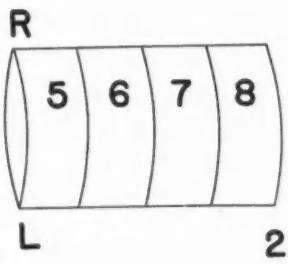
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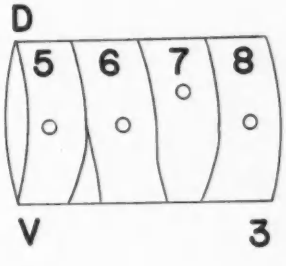
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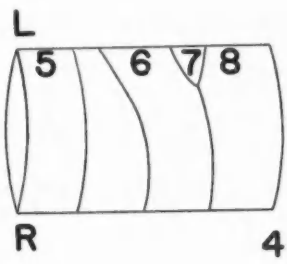
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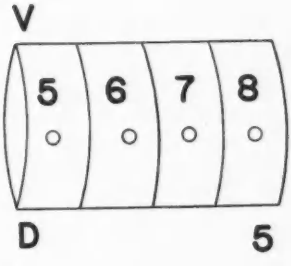
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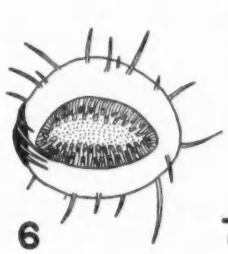
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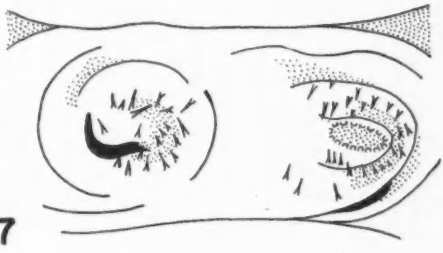
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The prolegs on segment six of this specimen were not fully developed. That on the left side possessed a reduced coxa and sclerotic plate. All other parts including the planta and crochets were absent (figures 6 and 7). The right proleg was but slightly more developed with its sclerotic plate, coxa, and planta approximating normality. Rudimentary crochets were visible. Even the number, location, and appearance of the hairs associated with this appendage were altered. All these defects were not inherent anomalies but rather were secondary defects accompanying the spiral segmentation.

One caterpillar lacked an entire segment. There were but four pairs of prolegs instead of the usual five and but eight pairs of spiracles. Segment seven was one fourth again as long as normal. It is fairly obvious that segment six had been omitted.

The three abnormal larvae just considered were observed four hours after emergence from the egg. Close observation of the four during each instar revealed no change. Had it been possible to carry them through to the imago stage, the segmental irregularities would have been present unchanged in the adults. The defects were apparently not detrimental since the larvae experienced little or no difficulty in carrying out normal functions. The eccentrically placed proleg on segment seven was supplied with a complete set of muscles. It exhibited all the normal movements associated with locomotion though it was at no time in contact with the substratum.

ANOMALOUS LEG SEGMENTATION

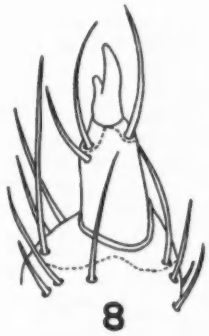
Thirteen larvae in addition to the three just discussed had defects in thoracic leg structure. From Table I it may be seen that there was little regularity either in the form or the loci of the defects. The average number of malformed legs per individual was two; the maximum, five. Most common was the absence of pretarsi (14 instances) (figure 9). There were ten cases of "telescoped leg," a condition typified by dwarfed, absent, and malformed segments (figures 15 to 18). In six instances the pretarsi were abnormal (figure 10). Seven legs lacked a tibia as well as a tarsus (figures 12 and 14). No one leg seemed more prone to malformation than another.

This analysis suggests that the defects were simply an outward manifestation of some inherent functional or developmental defect.

In contrast to larvae possessing spiral segmentation these with malformed thoracic legs were handicapped to varying degrees depending upon the number of legs affected. Some individuals moved about on the blades of grass only with the greatest of difficulty. Others experienced trouble at the moulting period.

EXPLANATION OF PLATE II

Fig. 8. Tip of normal thoracic leg. Lateral view. 9. Tip of thoracic leg lacking pretarsus. Lateral view. 10. Tip of thoracic leg with abnormal pretarsus. Lateral view. 11. Lateral view of normal thoracic leg. 12. Thoracic leg lacking tibia. Lateral view. 13. "Telescoped" thoracic leg. Lateral view. 14. Thoracic leg lacking tibia. Lateral view. 15. "Telescoped" thoracic leg. Lateral view. 16. Same. 17. Same. 18. Same.



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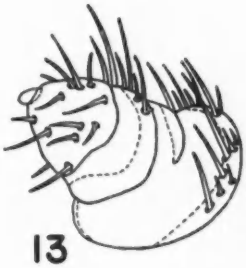

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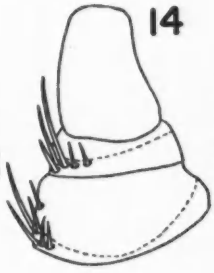

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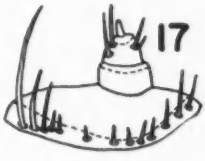

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CAUSE

Anomalous segmentation in *Drosophila* is a well known phenomenon. Morgan (1915) studying the genetics of such phenomena in great detail found that irregularities in abdominal segmentation may be of several types as regards mode of origin. First, they may follow injury to larvae or pupae. Second, they may be inherited in the sense that they occur

TABLE I

NUMBER AND LOCI OF ABNORMAL THORACIC LEGS IN ONE BROOD OF *P. manataaqua*

Larva No.	First Right Leg	First Left Leg	Second Right Leg	Second Left Leg	Third Right Leg	Third Left Leg
1	Abnormal pretarsus	Lacking pretarsus	Abnormal pretarsus		Abnormal pretarsus	Lacking pretarsus
2		Lacking tibia		Abnormal pretarsus	Telescoped	Abnormal pretarsus
3	Telescoped	Lacking pretarsus	Abnormal pretarsus	Lacking pretarsus		
4	Telescoped	Lacking pretarsus	Lacking pretarsus		Telescoped	
5				Lacking tibia		
6		Lacking pretarsus	Lacking tibia	Telescoped		
7					Telescoped	
8	Telescoped		Lacking pretarsus			
9	Lacking pretarsus	Lacking pretarsus				
10		Telescoped			Telescoped	Telescoped
11	Lacking pretarsus			Lacking pretarsus		
12						Lacking tibia
13			Lacking pretarsus			
14	Lacking tibia					
15					Lacking tibia	
16				Lacking pretarsus		Lacking tibia
Total abnormalities	7	7	6	6	6	5

in certain stocks in more or less definite percentages and may be due to multiple factors. Third, the condition of the medium on which the flies are bred, therefore the environment, greatly influences the incidence of abnormality. It may be added that faulty pupal reorganization may also cause similar irregularities.

While the anomalies of *Drosophila* are for the most part postembryonic, those of *P. manataaqua* belong in an entirely different

category since they may be traced back to the egg. No direct environmental effect is responsible since the eggs of this and other normal broods were laid under similar and constant environmental conditions. The only important environmental factors to which the eggs were subject were temperature and humidity. Unlike *Drosophila*, *P. manataaqua* larvae were exempt from nutritional factors. The temperature was that of the natural habitat of the species. Any difference in humidity, if existent, was slight. While it is true that certain environmental changes might favor the appearance of these defects, the tendency to produce anomalies of this kind is apparently a genetic one.

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SEVENTH PACIFIC SCIENCE CONGRESS

The Seventh Pacific Science Congress is scheduled to be held in Manila in November, 1943, under the auspices of the National Research Council of the Philippines. Problems related to entomology of the Pacific will be given an important place in the Congress under the following main subdivisions: (a) insects in the Pacific; (b) biological control of insects in the Pacific; (c) plant quarantine.

Opportunities to visit parts of Luzon and the southern islands of the archipelago will be afforded through the various excursions planned in connection with the Congress. Tropical virgin forests within easy access from Manila provide excellent collecting grounds. Entomologists who are intending to attend this Congress are invited to communicate with Dean L. B. Uichanco, Secretary, Section of Economic Entomology, Seventh Pacific Science Congress, Agricultural College, Laguna, Philippines.

L. B. Uichanco, *Secretary*,
Section of Economic Entomology.

EFFECT OF LENGTH OF DAY ON THE ACTIVITY AND HIBERNATION OF THE AMERICAN DOG TICK, DERMACENTOR VARIABILIS (SAY)

(Acarina: Ixodidae)

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The American dog tick (*Dermacentor variabilis* (Say)), vector of Rocky Mountain spotted fever in the Eastern States, is a species of rapidly increasing economic importance. A point of more than ordinary interest in a consideration of its biology is the question of what factors induce hibernation. On the island of Martha's Vineyard, Mass., both larval and adult ticks hibernate in large numbers, whereas the number of nymphs that hibernate may be large or small, varying from year to year. From the end of March or the middle of April (depending on the temperature) until the end of September larvae and nymphs are active in seeking their hosts, as indicated by the large numbers on meadow mice and deer mice. From October to March they are in hibernation, no ticks occurring on mice in severe winters and only occasional specimens being found engorging in mild winters; but in the vicinity of Washington, D. C., hibernation of larvae and nymphs is less complete. The season of adult tick activity is from April to the end of August, and hibernation of the adults is complete, both at Martha's Vineyard and at Washington.

Although it is well known that low temperatures retard tick activity, at Vineyard Haven on the island of Martha's Vineyard the average temperature of October, when the last stragglers are ceasing activity, is as high as that of May, when activity is at its height, and the temperature of November, when all activity has completely stopped, is as high as that of April, when spring activity is well under way. Also, in the case of indoor experimental infestations, ticks do not attach so readily in winter as they do in summer. The season of tick activity is roughly from March 21 to September 21, and the characteristic which these two dates have in common is not the temperature but the length of daylight. Although botanists and vertebrate physiologists have done considerable work on

the effect of the length of daylight, entomologists apparently have given less attention to this subject. It has, however, been demonstrated that the gradually shortening days of late summer bring on the fall brood of winged migrants among certain species of aphids (Marcovitch, 1924), (Shull, 1928, 1929) and that an artificially increased period of illumination stimulated activity and development in hibernating stages of certain mosquitoes (Baker, 1935).

METHOD

To test the effect of the length of day (the photoperiod) on the activity of ticks, two lots each of larvae, nymphs, and adults, each lot identical in age and conditions of rearing, were selected and treated as follows: One lot of each stage was kept in glass tubes with packed-soil bottoms and cloth tops, set in moist sand at room temperature, and exposed to normal daylight; the other lot of each stage was kept under similar conditions but exposed to an extended and increasing photoperiod consisting of normal daylight supplemented by electric light supplied by an ordinary frosted glass, 25-watt bulb. At intervals specimens from each lot were placed on appropriate hosts to test their willingness to attach and engorge. The larvae and nymphs were exposed to the same conditions of normal or extended light while on their hosts (about 7 days) as while awaiting a test, as they were engorged on meadow mice in one-quarter-inch mesh wire cages beside the tubes of ticks. The adults were engorged on rabbits in closed metal cells into which no light could penetrate. A high proportion of engorgement was obtained by both these methods during the season when ticks were normally active.

EXPERIMENTS DURING FIRST WINTER

This experiment was conducted for two winters. For the first winter the exposure to an artificially increasing photoperiod began October 17, 1938, when the normal photoperiod was equal to that of February 22. Each day the electric light remained on a few minutes later in the evening, so that by November 1 the extended photoperiod was equal to the normal photoperiod of April 7 and the first engorging test was made. By November 13 the artificial photoperiod was equal to that of May 12, and from then on it was increased at the same rate as the normal spring increase, so that each successive day was equal to the equivalent succeeding day in spring. The temperatures of the rooms in which the two groups of ticks were kept varied considerably from day to day, but the temperatures of both rooms rose and fell together, the difference between the average temperatures of the two being less than 1 Fahrenheit degree as recorded on thermometers within 3 inches of the ticks.

In the comparison of the two groups of larvae 120 specimens from each group were used in each test. Sixty were placed on each of two meadow mice, to reduce as far as possible differences caused by varia-

TABLE I

EFFECT OF AN EXTENDED PHOTOPERIOD ON ACTIVITY OF THE IMMATURE STAGES OF *Dermacentor variabilis** AS INDICATED BY THEIR READINESS TO ENGORGE ON MEADOW MICE

Date Infested	Ticks from Normal Photoperiod								Ticks from Extended Photoperiod								Day of Equivalent Photoperiod in Nature
	Length of Photoperiod		Larvae Engorging			Nymphs Engorging			Length of Photoperiod		Larvae Engorging			Nymphs Engorging			
1938			Host 1	Host 2		Host 3	Host 4				Host 5	Host 6		Host 7	Host 8		
	Hrs.	*Mins.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*Hrs.*	*Mins.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Nov. 1	10	31	(†)	1		0	0		12	53	9	6		0	1		April 7
Nov. 9	10	13	10	8		0	0		13	51	34	28		0	2		April 30
Nov. 16	9	59	6	4		0	1		14	22	14	9		(†)	(†)		May 15
Nov. 22	9	48	(†)	6		(†)	(†)		14	33	36	30		(†)	1		May 21
Nov. 30	9	35	(†)	4		2	1		14	45	35	23		(†)	9		May 29
Dec. 7	9	27	(†)	23		(†)	0		14	53	(†)	52		(†)	(†)		June 5
Dec. 14	9	21	33	26		3	3		14	59	58	55		30	25		June 12
Dec. 20	9	20	38	29		0	1		15	01	49	55		30	24		June 18
1939–40			Host 1	Host 2	Host 3	Host 1	Host 2	Host 3			Host 4	Host 5	Host 6	Host 4	Host 5	Host 6	
Oct. 10	11	20	28	(†)	(†)	0	(†)	(†)	13	16	35	21	9	4	3	2	April 13
Oct. 13	11	12	26	21		0	0		13	23	36	22		0	4		April 16
Oct. 24	10	42	8	17	6	0	0	0	13	53	21	13	18	0	2	2	April 27
Nov. 10	10	0	11	8	16	2	0	1	14	33	88	77	82	2	6	2	May 14
Dec. 1	9	20	7	21	4	2	3	0	15	08	66	78	62	25	23	24	June 4
Dec. 18	9	05	15	16	20	1	0	2	15	17	69	67	68	24	23	22	June 21
Jan. 15	9	23	10	8	13	5	3	3	14	53	27	(†)	19	17	(†)	19	July 19
Feb. 8	10	14	44	52	21	13	11	9	14	03	8	12	32	3	6	1	Aug. 12
Feb. 27	11	06	80	64	61	9	3	8	13	14	23	23	13	8	5	2	Aug. 31
Mar. 22	12	11	04	55	49	22	22	16	12	08	21	27	20	22	21	7	Sept. 24

* In the 1938 records 60 larvae *or* 30 nymphs were placed on each of the 8 mice.
In the 1939–40 records 100 larvae *and* 25 nymphs were placed on each of the 6 mice

† Host died.

tions in individual host susceptibility to the parasites. The meadow mice were confined in wire cylinders, wrapped in cloth, and the ticks were given 6 hours in which to attach themselves to the host. Nymphs were tested in the same manner except that only 30 were placed on each mouse. Adult males and females were tested by placing them in engorging cells on opposite sides of a domestic rabbit.

RESULTS

The results obtained with the larvae and nymphs are shown in Table I. In the case of the nymphs no comparison can be made in three instances owing to the fact that both mice of one group died. The mean temperature on the day of attachment had some influence on the number of ticks attaching, but this of course applied to both experimental and control lots alike. The condition of the mice also influenced results, as on some days freshly caught mice were available, whereas at other times it was necessary to use mice that had been in captivity for some time and had been used repeatedly as hosts. Here again, however, the variation was between different days and not between the different groups on the same day.

The lengths of the normal and extended photoperiods were calculated from the time of sunrise and sunset as listed in almanacs in the case of the former, and from sunrise until the light was extinguished in the case of the latter. The day of equivalent photoperiod for the latter was determined from the time of sunrise and sunset for each day, as listed in almanacs.

In every instance the ticks that had been exposed to a long photoperiod engorged much more readily than the controls. This was particularly noticeable in the case of the nymphs in the longest periods, where as many as 100 per cent of the ticks exposed to the extended photoperiod engorged, while no more than 10 per cent of those exposed to normal winter daylight attached.

The results with adults showed no correlation between the length of the photoperiod and the proportion of females engorging. In one case, more conditioned ticks attached, more engorged, and they dropped sooner than in the checks. In another case, more control ticks attached, but more conditioned ticks completed engorgement and they dropped sooner. In a third case, more control ticks attached and completed engorgement, but the engorging period was delayed beyond that of the conditioned ticks. In a fourth case, more control ticks attached and engorged, and they dropped sooner than did those in the conditioned group.

EXPERIMENTS DURING SECOND WINTER

When the experiment was repeated during the winter of 1939–40 the technique was improved in several ways. During the previous year the mice used were sometimes freshly caught, sometimes caged for several months. Considerable mortality was experienced among the caged mice, and in addition there was a possibility that records from them might not be comparable to records made at other times from freshly caught mice. Of course all mice used in any one comparative test were in the same condition. In 1939–40, however, only freshly caught mice

were used in all tests, giving a more accurate basis for comparison and largely eliminating host mortality. Also three mice were used as hosts for each test group instead of two, reducing the element of individual host desirability still more than the previous year. Both larvae and nymphs were placed on each of the three mice, so that the real effect of host desirability could be determined. Adults were engorged on a dog, a more normal host than rabbits.

The handling of the ticks and exposure to an extended photoperiod was the same as before, except that the experiment was begun September 20 when the normal photoperiod was equal to that of March 24, and the artificial photoperiod was extended enough each successive day to equal the extended light period of a succeeding day in spring or summer. By December 18 it was equal to June 21, the maximum, and it was then reduced each day until March 21, when it again became equal to the normal photoperiod.

Also in 1939–40 there was more difference in the temperatures to which the two groups of ticks were subjected. Those given the increased photoperiod were kept in a room which averaged 5° F. colder than that containing the normal photoperiod group. This resulted in eliminating the possibility that increased activity among the treated ticks might be due to higher temperatures, perhaps raised by radiation from the electric light. The ticks were 30 inches and the hygrothermograph was 54 inches from the light bulb. On one occasion, when the hygrothermograph registered 73° F. in its normal location with the light on, it was moved to the exact place where the ticks were kept. In 2 hours the temperature recorded had not risen perceptibly. The room temperature for the ticks exposed to the normal photoperiod was also recorded on a hygrothermograph within 2 feet of the tubes of ticks.

The extended photoperiod produced a pronounced increase in the number of larvae and nymphs engorging on meadow mice, confirming the work of the previous year. The exact records are shown in the lower part of Table I. It will be noted that the effect on nymphs was apparent as early as in the case of the October 10 (=April 13) lot, and the effect on larvae as early as in that of the October 24 (=April 27) lot, although at this time the best individual record among the normal ticks was still better than the poorest individual record among the conditioned ticks. The influence of the extended photoperiod was much more complete in the case of nymphs than of larvae.

As soon as the extended photoperiod passed its peak and the length of light period began to decline, corresponding to the shortening days of summer, the difference in activity between the conditioned ticks and the ticks exposed to normal, but now increasing, daylight was less marked, as seen in the January 15 (=July 19) record. By February 8 the ticks exposed to normal, increasing daylight engorged better than those exposed to the greater, but decreasing, photoperiod equivalent to August 12. It will be remembered that the former were exposed to a slightly higher temperature.

That individual host desirability was not important in producing differences in the records from individual mice is indicated by the fact that the mouse producing the greatest number of engorged larvae did not consistently produce the greatest number of engorged nymphs, nor

did the mouse producing the smallest number of engorged larvae consistently produce the smallest number of engorged nymphs.

As in 1938, the extended photoperiod had no influence on the number of adults attaching to a dog.

SUMMARY

To test the influence of the photoperiod, or length of daylight, on the activity and hibernation of the American dog tick (*Dermacentor variabilis* (Say)), larval, nymphal, and adult ticks were exposed to artificially extended photoperiods, and their activity, as indicated by their readiness to engorge, tested against that of comparable lots exposed to normal winter daylight. This experiment was conducted for two winters, and it was found that larvae and nymphs exposed to lengthening artificial photoperiods corresponding to those of March 24 to June 21 engorged much better than those exposed to the normal, decreasing photoperiod from September 20 to December 18, even with slightly higher temperatures in favor of the latter. When the artificial photoperiod passed its peak and began to decrease, corresponding to the shortening days of July, the difference between the behavior of ticks exposed to it and of those exposed to the normal photoperiod of the lengthening days of January was not so great, and by February, when the artificial photoperiod resembled that of August, those from the warmer, normal-day room were most active.

The increased photoperiod had no effect on activity of adults during either winter.

CONCLUSIONS

1. The length of day is an important factor in controlling the activity or hibernation of larvae and nymphs of *Dermacentor variabilis*.

2. Long photoperiods are more favorable to activity than short ones, and gradually increasing photoperiods more favorable than gradually decreasing ones of even greater absolute length.

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NOTES ON ECUADORIAN BUTTERFLIES—I
STEROMA, PSEUDOSTEROMA AND STEREMNIA
(Satridae, Rhop.)

F. Martin Brown,
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These three names have been applied to a small group of dull and inconspicuous Andean satyrids. Until Thieme erected *Steremnia* in 1906 the described species were grouped under Westwood's name, *Steroma*. In 1912 in the revision of the American Satyridae written by Weymer for Seitz' "Macrolepidoptera of the World" the third genus, *Pseudosteroma*, was defined.

While working over the material collected by my party in Ecuador during 1938–39, I have had the opportunity of critically examining series of the species composing the aggregation and feel that Weymer's genus, *Pseudosteroma*, is superfluous. His diagnosis of the genus is based upon the marked differences in the contours of the wings of this group of species when compared with *Steroma*. The differences in contour he points out as setting the group apart from *Steremnia* are much less marked and I believe not valid. I can find no critical items that may be used singly or in combination that will separate Weymer's genus from Thieme's. The species included in these genera in Seitz' appear to represent a continuous series in regard to wing form, pattern, scent-patches and genitalia of the males, and such minor characters as the hairiness of the eyes and the palpi. Since there is no obvious need for two names I propose to reduce *Pseudosteroma* Weymer 1912 to the synonymy of *Steremnia* Thieme 1906.

Between *Steroma* Westwood and *Steremnia* Thieme there are several differences in structural characteristics more important than the wing shape. The male scent-patch of *Steroma* consists of a large but not conspicuous group of long, black, silky hair-scales in the cell margining the M_3 vein and pointing marginad between the origins of the M_1 and M_2 veins. The patch in *Steremnia* is a broad band of raised scales that give a velvety appearance to the middle third of the wings from the costal margin to the inner margin of the forewings. This band varies somewhat in width among the species con-

stituting the genus. It is widest in *pronophila* and quite narrow on *monachella*.

The male genitalia of *Steroma* is not greatly different from that of *Steremnia*. In general, that of *Steroma* is more lightly built, notwithstanding that the insects are a little larger than *Steremnia*. The sacus is proportionately much longer in *Steroma* than in *Steremnia*. The dorsal margin of the valves is concave in *Steroma* and sharply humped in *Steremnia*. The aedaeagus is armed with a few teeth on the distal margin in *Steroma* while it is usually so armed at least over the distal half in *Steremnia*. (*S. pronophila* seems to lack these teeth.) The minutiae of the structures are sufficiently different from species to species to be of some taxonomic value.

The following notes concerning the species we collected may be of interest.

Steroma Westwood

1851, Genera of Diurnal Lepidoptera, p. 400.

Type: *Steroma bega* Doubleday and Hewitson.

S. bega andensis Felder

1867, Reise Novara, Lepidoptera 3: 475, no. 814.
Type locality: Bogata, Colombia.

Range: The species ranges from Venezuela to Bolivia, the race is found in Colombia, Ecuador and possibly northern Peru.

Ecuador: Runtún, near Baños, Tungurahua, 2100 m. 1 male 26. xi. 38. Rio Blanco, near Baños, Tungurahua, 1900 m. 1 male iii. 38 (W. C.-M.) Yungilla, near Baños, Tungurahua, 1700 m. 2 males 24, 27. v. 29. (W. C.-M.).

Our few specimens were taken in the wet sub-tropical forest near its juncture with the temperate rain forest. The altitudes on the three specimens collected by natives for Macintyre (W. C.-M.) may be incorrect.

Steremnia Thieme

1906, Berliner entomologische Zeitschrift 50: 137.
Type: *Steremnia rugilas* Thieme.

KEY TO THE SPECIES FOUND IN ECUADOR

1a. Submarginal row of whitish dots clearly evident on the underside of the hindwings.....2
b. This row not clearly evident.....**rugilas**
2a. A rather large creamy patch on the underside of the hindwings on the inner margin near the anal angle.....**monachella**
b. This patch lacking. The patch of scent-scales on the upperside of the forewings of the males occupying about one-third of the wing area..**pronophila**
c. This patch obscure, a heavy dusting of gray scales on the marginal portion of the wings. The patch of scent scales small.....**misella**

S. pronophila Felder

1867, Reise Novara, Lepidoptera 3: 475, no. 815.
Type locality: "Bogata," Colombia.

Range: The Andes from Colombia to Peru.

Ecuador: Rio Blanco, near Baños, Tungurahua 2000 m. 1 male 18. x. 38 (W. C.-M.) and 1900 m. 1 male 21. iv. 39 (W. C.-M.). Yungilla, near Baños, Tungurahua, 1800 m. 2 males v. 38 (W. C.-M.) and 1700 m. 1 male v. 39 (W. C.-M.). A sixth specimen from Macintyre bore a locality and altitude that is impossible, "Rio Toachi, 600 m." This specimen was probably purchased by Macintyre in Quito from some native bird collector. The specimen doubtlessly came from somewhere between Quito and Saloya on the western slope of the Cordillera Occidental in the upper part of the forest.

Each of the classic reports on the high altitude butterflies of Ecuador includes the species. Godman and Salvin in reporting upon the material collected by Whymper report some specimens as "nr. *Steroma pronophila*" from Machachi, 3000 m. which I believe to be the next species. Although Weymer reported six specimens among the butterflies brought out by Stübel he did not include Ecuador in the range of the species in his discussion of it in Seitz. One of these Stübel specimens was taken at Pallantaga, 2200 m., on the slopes above the town. This specimen is probably *pronophila*. The others were taken between 3000 m. and 3700 m. and are more likely *monachella*. Conditions in Europe prevent me from verifying this surmise through Dr. Hering in Berlin. Dognin reported the species among the material collected for him by Abbé Gaujon but gave no data other than "the vicinity of Loja," which in his sense is very broad, covering everything from the humid tropics to the paramos.

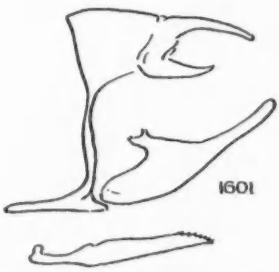
S. monachella Weymer

1912, Seitz' Grosseschmetterlinge um die Erde 5: 241, pl. 52, f. a-1.
Type locality: Huancabamba, Peru.

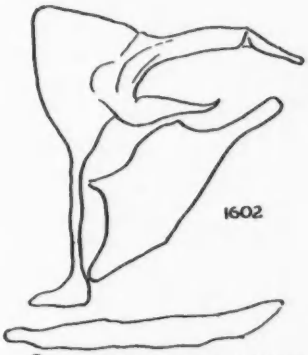
Range: The Andes of Peru and Ecuador.

Ecuador: Hda. Talahua, Bolivár, 2900 m. 3 males, 4. v. 39, and 3000 m. 7 males, 2 females, 28. iv-4. v. 39. Lago Cuicocha, Imbabura, 3300 m. 5 males, 28–31. v. 39, and 3500 m. 2 males, 31. v. 39. Isla Chica, L. Cuicocha, Imbabura, 3300 m. 2 males, 29. v. 39.

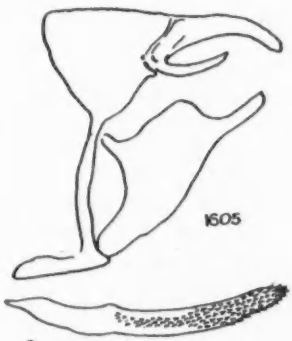
This is one possibility for the species reported as *S. pronophila* and "nr. *S. pronophila*" from the high dry interandean plateau. Such conditions prevailed at Cuicocha—except on



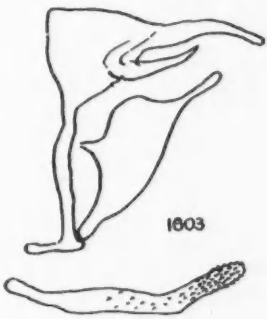
STEROMA BEGA ANDENSIS



STEREMNIA PRONOPHILA

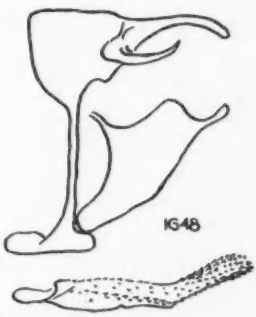


STEREMNIA RUGILAS



STEREMNIA MONACHELLA

Hair-scales on ♂ STEROMA



STEREMNIA MISELLA

the island, which was clothed in a rain forest in great contrast to the surrounding country. It seems to be a species closely associated with the grasslands and paramo. Of the three species in the genus that we found at Lago Cuicocha, only this one was taken on the small island in the lake. The others occurred with it on the mainland.

S. misella Thieme

1906, Berliner entomologische Zeitschrift 50: 138.
Type locality: Huancabamba, Peru.

Range: Northern Peru through Ecuador, in the Andes.

Ecuador: Lago Cuicocha, Imbabura, 3300 m. 1 male, 31. v. 39, and 3600 m. 2 males, 1 female, 31. v. 39. Hda. Talahua, Bolivár 3100 m. 1 male, 3. v. 39.

Our material compares favorably with Thieme's figure of the type. The species is restricted to the paramo and, apparently, the western cordillera.

S. rugilas Thieme

1906, Berliner entomologische Zeitschrift 50: 137.
Type locality: Quindui Pass, Colombia, 3000 m. (Fassl).

Range: Colombia and Ecuador and possibly northern Peru.

Ecuador: Ria Loma, Seville de Oro, Azuay, 3000 m. 1 male, 14. ii. 39. Urbina, Chimborazo, 3650 m. 11 males, 3 females, 18. iv. 39. Hda. Talahua, Bolivár, 3100 m. 7 males, 29. iv-3. v. 39. Tiupullo, Pichincha, 3450–3500 m. 13 males, 6. xi. 38. Cerro Pasachoa, Pichincha, 3300 m. 8 males, 1 female, 12. xi. 38. 3450 m. 3 males, 14. xi. 38. Lago Cuicocha, Imbabura, 3200 m. 1 male, 28. v. 39. 3500 m. 1 male, 31. v. 39. 3600 m. 1 male, 1 female, 31. v. 39.

It is curious that neither Whymper nor Stübel collected this species in Ecuador. Although this may be the species reported as *pronophila* from the higher altitudes by the older authors, the underside of *rugilas* is so distinct from that of *pronophila* and *monachella* that I feel it is more reasonable to believe that the confusion existed between the latter two insects.

We found *rugilas* abundant on the paramos. At Urbina, a female was observed laying eggs on the stiff bunch-grass (*Festuca?*). The insect is well distributed in both cordilleras from north to south. Our specimens show a great deal of variation on the underside of the hind-wings. They compare much more favorably with Weymer's description in Seitz' than with his figure. Only two of the males are as dark as the illustration in my copy of the work.

A NEW DORYCEPHALUS
(Homoptera: Cicadellidae)

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Columbus, Ohio

Dorycephalus delongi n. sp.

A very narrow, long, thrice-ridged vertex distinguishes this from other Dorycephali. Nymphs are usually green and adults tan with fuscous to black markings. Length: 14 mm.

Male.—General color greenish to light tan with dark markings as follows: apex of vertex, small rounded spot common to median margin of vertex and pronotum, median elongate spot from base of scutellum across margin of pronotum, small triangle before apex of scutellum, abdominal segments sparsely lined and pygofers darkened; below, lateral margins of vertex dark between ridge and edge, legs and venter darkened posteriorly. One specimen is very dark brown throughout with red eyes and lateral strip before and after eyes pale.

Vertex 3½ mm. long, 1 mm. wide at eyes, foliaceous, tip slightly upturned; three prominent ridges, median extending to apex and lateral broader, almost attaining apex; narrowed distinctly above eyes, then parallel-margined to evenly rounded apex; face, apical third strongly concave, strong lateral ridges arise at inner base of antennae and extend to apical concavity, clypeus rectangular, small, longer than broad, cheeks large, inflated, outer corner almost a right angle, vestiture of fine white hairs, especially basally.

Pronotum slightly wider than long, anterior margin straight, curved sharply caudad at eyes; lateral margins parallel; posterior margin with sides rounding to narrow median excavation, depth one-fifth length of pronotum; ridges of vertex persist across pronotum; scutellum equilaterally triangular with raised apex, pair of median impressed points equidistant from sides and each other, and in some specimens, longitudinal median depression is evident; elytra of type specimen extending to third abdominal segment, venation simple, rugose, in some males elytra extend to sixth segment.

Genitalia.—Valve hardly discernible, as slight projection from segment; plates long, narrowing rapidly from base to long appressed narrow apices, twice as long as combined basal width; pygofers with long, narrow foliaceous apical processes, as long as head, inner pygofer exposed ventrally, covered thickly with long white hairs, short white pile over entire body, heavier on ventral genital surface.

Female.—Vertex 4 mm. long, 1.1 mm. wide. Last ventral segment as long as preceding with lateral angles roundingly angulate to produced, broad median lobe which extends well beyond them.

Distinguished from *knulli* by definite lateral ridges on vertex and external genitalia in both sexes, and from *vanduzei* by narrower vertex which is longer in proportion to its width than in that species.

All specimens are placed in the collection of The Ohio State University, and were collected in 1940 by D. J. and J.N.Knull. Male holotype, Uvalde Co., Texas, vi-26, and nymph; allotype, Lincoln Co., N. M., vii-9, four paratypes and nymphs; additional paratypes and numerous nymphs from Texas, Blanco Co., vi-20, Kinney Co., vi-27 and Val Verde Co., vi-28.

INSECT PESTS OF STORED GRAIN AND GRAIN PRODUCTS. IDENTIFICATION, HABITS AND METHODS OF CONTROL, by RICHARD T. COTTON. 242 pages, 93 illustrations, 10 tables, 5½ x 8¾ inches, paper. 1941. Published by the BURGESS PUBLISHING COMPANY (Mimeoprint and Photo Offset Publishers), 426 South Sixth St., Minneapolis, Minn. Price, $3.00.

If any group of economic entomologists were asked to name the man best qualified to write a book on insect pests of stored grain and grain products, Dr. R. T. Cotton would certainly be chosen. Working for 20 years in the Bureau of Entomology and Plant Quarantine on all phases of biology and control of stored product insects, he has contributed to our knowledge of such insects, to the discovery and application of new fumigants, to the principles of fumigation and of late years to the solution of practical pest control problems in grain bins, elevators, mills and warehouses. How well he has taken advantage of his opportunity to serve an important industry is demonstrated by the present book.

Although Dr. Cotton has not provided a preface, the reader soon finds that the book was written primarily to help those who are concerned, directly or indirectly, with the control of insect pests of stored grain and grain products. He gives only enough information about the insects themselves, about the principles of fumigation and fumigants to enable the reader intelligently to choose or to apply the control measures that are recommended. He has not attempted to explain elevator and mill machinery and operations to entomologists.

The contents of the book are well arranged. Beginning with a survey of the insect pests concerned, Dr. Cotton takes up in order the control of the pests in stored grain on the farm, in elevators and warehouses, in flour mills, and in stored flour. As fumigation is the principal method of control there follow chapters on the principles of fumigation, on the common fumigants, and on fumigation procedures in mill and warehouse, and in atmospheric and vacuum chambers. The final chapter (No. 11) deals with heat sterilization in the flour mill. In order to make each chapter complete, Dr. Cotton sometimes repeats information given in other chapters.

The book is unusual in having a loose-leaf binding, which enables the reader to lay it open flat at any page. The photo offset process employed gives a clear, readable reproduction of the typing. The illustrations, however, suffer by this method of reproduction, losing something in sharpness. However, they adequately portray the subject.

At the time Dr. Cotton's book was received, this reviewer was particularly anxious to know the present status of grain and mill insects and their control. The book completely satisfied the reviewer's needs and therefore should do the same for others. It should be in the hands of every entomologist who is or may be consulted about the control of stored grain and mill insects or who presents such information in teaching. Of course it should be widely distributed in the industry. Finally, the book will suggest many opportunities for research that are needed to extend our knowledge of the principles and practices of control of stored product insects.—F. L. C.

THE NATURE OF INJURY TO ALFALFA CAUSED BY EMPOASCA FABAE (HARRIS)[1]

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Entomologists and plant pathologists have observed for many years that a small green leafhopper scientifically known as *Empoasca fabae* (Harris) is capable of causing serious injury to a great number of plants, many of which are of economic importance. It is the only known species among leafhoppers in the United States which causes such widespread destruction and characteristic injury to plants. Scientists working with the insect have speculated on reasons for such pathological results following its attack, and theorized on the nature of its injury. One group has recently proposed that the feeding leafhopper mechanically plugs the vascular elements in the plant and thereby causes the symptoms of injury. The other group adheres to the theory of plant toxaemia resulting from inoculation of a toxin by the insect during its feeding period. There is a need, therefore, to discover fundamental facts which explain the nature of the insect's injury and to determine if the answer lies with one theory or the other, or perchance is a combination of the two.

In approaching this problem, the writer was aware of the complexity of the inherent factors of insect or plant which determine the nature and degree of injury. More especially, however, was he aware of the greater complexity caused by an interrelationship of insect and plant factors. This would need to be unraveled before any basic conclusion could be reached concerning the real cause of injury. For example: if the causal factor of the insect is thought of only as the feeding puncture (excluding for a moment that it is a mechanical or salivary effect), it must be that symptoms of reaction by the plant are influenced by a multitude of other factors such as the species of plant attacked, its age and vigor, the location of the puncture or even the kind of cells which are about the puncture. Correlate these factors with the complex physiological plant changes induced by the injury, and it is seen that

[1]A condensed portion of a thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

one has a task of very precise differentiation of the role of each factor before the symptoms can be attributed to any specific fundamental cause. To further complicate the matter, only external symptoms are commonly used to indicate the presence of injury. These symptoms make a delayed appearance, and certainly can be distant from the site of the original puncture.

One method to discover the primary effect of the leafhopper's feeding is to make a histological study of injured tissue. Previous experiments have demonstrated that typical symptoms of injury appear on an alfalfa leaflet when an individual leafhopper is confined on it, and by this procedure a gradual progression of symptoms takes place. In leaf tissue a great amount of obstruction would be necessary to disrupt translocation processes of numerous veins and veinlets. It follows that the most fundamental information on the true nature of injury by *E. fabae* should be gained in studies of a leaflet fed upon by only one insect and for a relatively short period of time.

EXPERIMENTAL

The terminal leaflet of an alfalfa plant was exposed to the feeding activity of an individual leafhopper by means of small cages. Three species of leafhoppers were used, and the series was duplicated to give a total of six terminal leaflets. It was to insure a comparable study that two species besides *E. fabae* were used: one, *Aceratagallia sanquinolenta* (Prov.), was selected because it normally feeds on alfalfa; the other, *Macrosteles divisus* (Uhl.), was chosen because, although it normally does not feed on alfalfa, it is known to feed on vascular tissues of asters and other plants. After a three-day confinement the cages and insects were removed from all leaflets. Immediately one leaflet fed on by each species was killed and fixed in acetic-formalin-alcohol solution, the leaflet being divided at this time into four parts so that penetration would be rapid, and also so that the segment could later be identified with respect to its position in the leaflet. These segments were labeled "A" and numbered consecutively 1, 2, 3, 4, from the apex to the base. The remaining duplicate series of leaflets were observed for the days following, and about ten days later when the leaflet which had been exposed to *E. fabae* was beginning to show symptoms of injury, these leaflets were killed and fixed in the same manner as the first series, being labeled "B." At this time it was noted that no apparent symptoms of injury were found on the leaflets on which *A. sanguinolenta* and *M. divisus* had been confined.

The leaf segments were passed through the alcohol and xylol fluids used in histological techniques and embedded in paraffin from xylol. All sections were cut on the microtome at 10 microns, and fixed serially on slides, precautions being taken to number slides so that the proper location of a section in the leaflet could be determined. Delafield's haematoxylin and safranin were used for staining. A systematic study

of every section in each leaf was then made for the presence of sheaths secreted by the leafhoppers, notes were taken on their actual number,

TABLE I

THE LOCATION AND NUMBER OF SHEATHS SECRETED BY THREE SPECIES OF LEAFHOPPERS CONFINED FOR THREE DAYS ON ALFALFA LEAVES

(A—Leaflet killed immediately after removal of insect. B—Leaflet killed 9 days after removal of insect.)

Species	Leaf Segment	Total Sections	Sections with Sheaths	Total Sheaths
E. fabae (A)	1	352	22	4
	2	385	17	2
	3	398	52	11
	4	359	1	1
	Total	1,494	92	18
E. fabae (B)	1	313	153*	10
	2	318	129*	7
	3	291	0	0
	4	482	37*	2
	Total	1,404	219*	19
A. sanquinolenta (A)	1	341	2	1
	2	507	0	0
	3	316	3	1
	4	350	1	1
	Total	1,514	6	3
A. sanquinolenta (B)	1	324	0	0
	2	491	8	3
	3	432	4	1
	4	571	0	0
	Total	1,818	12	4
M. divisus (A)	1	275	5	2
	2	331	13	6
	3	275	11	7
	4	472	10	2
	Total	1,353	39	17
M. divisus (B)	1	500	40	15
	2	470	19	7
	3	459	4	2
	4	462	12	2
	Total	1,891	75	26

* Injured area around each sheath.

location and path of penetration, and search was made especially for any histological or cytological changes which might have taken place. A summary of these studies is given in Table I.

The writer feels that the scarcity of sheaths secreted by *A. sanguinolenta* in this experiment makes it impossible to reach a conclusion at the present time. If it is a normal habit, the location of the sheath in vascular tissues indicates that this species is capable of plugging vascular bundles, but the small number of punctures renders it unlikely that any injury would result from its doing so. A careful study of the cells in the vicinity of the sheath failed to reveal any changes in their normal appearance, and no great difference was observed to have taken place over the additional time of the "B" series.

The sheath secreted by *M. divisus* is not spread through many sections, but is an easily recognized, heavy deposit and so solidified that the central location of the insect's stylet is usually well defined by a clear empty space. The relatively large amount of salivary secretion would be capable of causing a great deal of plugging, and it was found that although many punctures ended in mesophyll tissue, a number also penetrated vascular bundles. A search for cellular changes about the sheath of *M. divisus* revealed no outstanding abnormalities. Fig. 1 shows the sheath of this insect in a leaflet nine days after the insect had been removed, and a careful examination of the cells around the sheath shows no recognizable changes in their appearance. It is to be noted that the well defined stylet tract within the sheath secretion is still visible, and the curved path definitely shows a search for vascular tissues.

The typical sheath secreted by *E. fabae* in alfalfa leaf tissue, and the effect of its secretion on surrounding cells is unique among the species of leafhoppers studied. In Table I it will be noted that in leaflet (A) there were found 18 sheaths distributed in 92 sections, or an average of 5 sections per sheath. This is decidedly in contrast with sheaths left by the other two species, which generally averaged less than 3 sections per sheath. A careful study of the material secreted by *E. fabae* failed to reveal a single well defined sheath. However, in all cases the path of penetration from epidermis to vascular tissue could be easily traced. The path is invariably irregular with disconnected bits of safranin-stained material scattered throughout the area of the puncture. In some cases mesophyll cells seemed to be emptied of their contents, but in no case could an authentic plugging condition in a vascular bundle be recognized.

A study of cells about the sheath deposition of *E. fabae* revealed marked abnormalities. Fig. 2 shows an early stage in cell changes which are initiated only in those cells in close proximity to the safranin-staining, elongated blotch of the sheath in the center of the leaflet. Above and to the left side are two darkly staining cells each with a prominent nucleus, and each nucleus has an outstanding, heavily stained nucleolus. Other cells distant from the sheath do not show nuclear changes. In several different sections containing other sheath depositions identical

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EXPLANATION OF PLATE I

Fig. 1 (Upper). Cross-section of alfalfa leaflet containing sheath (S) of *M. divisus* killed 9 days after removal of the insect. × 950.

Fig. 2 (Lower). Cross-section of an alfalfa leaflet caged 3 days with *E. fabae* showing early cellular changes about the sheath (S). × 570.

nuclear changes were noted along the sheath path, and in each case they were characterized by the enlarged nucleolus which stained a very bright red with safranin.

Fig. 3 gives a progressive change of the cells about the sheath deposition which can be seen only as a vague blotch in the photograph, but under the microscope is readily identified by its red stain. It can be seen that the nucleolus is very prominent, and that a very definite hypertrophy of the cells has taken place.[2] A study of other cells around these two enlarged cells shows irregularity of form in palisade and mesophyll tissue, and chloroplasts which are lightly stained in comparison with other parts of the same leaf section.

A histological study of the leaflet, in series "B" fed upon by *E. fabae* for three days and then allowed to live for nine days afterwards without the leafhopper before killing and fixing shows even greater abnormalities. It will be remembered that the visible symptoms of the leaf at this time were only a faint beginning of yellow blotching, and no marked injury was evident.

It was difficult to find a sheath of *E. fabae* in the sections, and those found were stained very faintly with safranin. But without exception it could be easily determined where the puncture had been made, for in the area of each sheath a pronounced hypertrophy of cells had taken place. Fig. 4 shows a cross section of a typical area where cells about the sheath have become hypertrophied and give the leaf section a distinct "cankered" appearance. Nineteen of these lesions were found in the leaflet studied.

In order to establish the fact that such abnormal areas were not the result of mechanical obstruction toward the base of the leaflet, their presence was accurately determined in the serial sections. The isolated occurrence of areas of hypertrophied cells and the presence of normal tissue above and below each "canker" definitely showed that hypertrophied cells had been initiated about the feeding puncture of *E. fabae* and were not due to any mechanical obstruction of vascular tissues.

Further study of each punctured area supports the conclusion that the condition is a result of cell stimulus about an irritant. Fragments of sheath material, staining very light red, could sometimes be found in the center of the "canker." The entire extent of injured areas averaged 10 sections, and of these probably not over 1 or 2 sections had identifiable sheath material. Furthermore, a study of the structure of the area shows largest cells in the middle and about the sheath fragments, while a definite tapering off occurs on each side until the hypertrophied cells merge with normal tissue.

Besides the hypertrophied cells around feeding punctures, the leaflet presented another condition which showed a significant histological abnormality. In the midrib of sections located in the second quarter of the leaflet a noticeable hypertrophy of phloem tissue progressively increased until it became quite marked in most sections of the third quarter, then progressively decreased until a close examination of the

[2]The writer has since examined several slides of feeding punctures by *E. fabae* in the possession of Dr. A. A. Granovsky, which likewise show nuclear changes in cells around the sheath.

midrib in the basal quarter of the leaflet failed to reveal any changes. No nuclear abnormalities were observed in the phloem cells, but the cytoplasm seemed to stain more darkly than normal tissue.

A careful search was made for the presence of red staining sheath material along the midrib, especially toward its basal part, but nothing could be found which would show that the hypertrophy resulted from a specific feeding puncture or was the result of a mechanical obstruction of any sort. Instead, the confinement of the hypertrophied cells to a region along the midrib, and the extensive occurrence of the condition through many sections as compared to the restricted hypertrophy around recognizable feeding punctures, leads to the conclusion that the salivary secretion is not strictly local in its effect. Some of the soluble material probably was translocated from a point of inoculation in the middle part of the leaflet, and as it was concentrated along the midrib the phloem cells of that region were incited to hypertrophy.

DISCUSSION

Previous work on the histology of leafhopper-injured tissues was reported by Granovsky (1930), who in an abstract stated that "studies show gradual disorganization and granulation of the plastids of affected tissue, clogging and isolation of vascular bundles by suberized or lignified layers and complete disorganization of the phloem region of severely injured tissue." Granovsky attributed these phenomena to enzymic secretions.

A more detailed study was reported by Smith and Poos (1931), who discussed the histological effect of confining insects to stem areas or to parts of alfalfa leaves. On the basis of finding secretions by the insect which "plugged" tubes of the xylem elements and ruptured and otherwise disorganized phloem tissue, these authors hypothesized mechanical obstruction.

It is supposed by the writer that the results reported in the studies of Smith and Poos were mostly dealing with abnormal results following the too close confinement of their insects. This supposition is strengthened by the following excerpt from their publication (1931, p. 278) in which it is noted that "because of the collapse of the cells, the early studies of the tissue which had wilted after exposure to adults of *fabae* resulted in a failure to determine which tissues they had fed upon. However, in later studies it was found possible to restore the flaccid or moderately wilted tissue to a condition approaching its original turgidity by submerging the small pieces desired for sectioning in distilled water for one or two hours before proceeding with usual fixation, dehydration and embedding." However, this view cannot be confirmed, because the investigators fail to give necessary information on the numbers of

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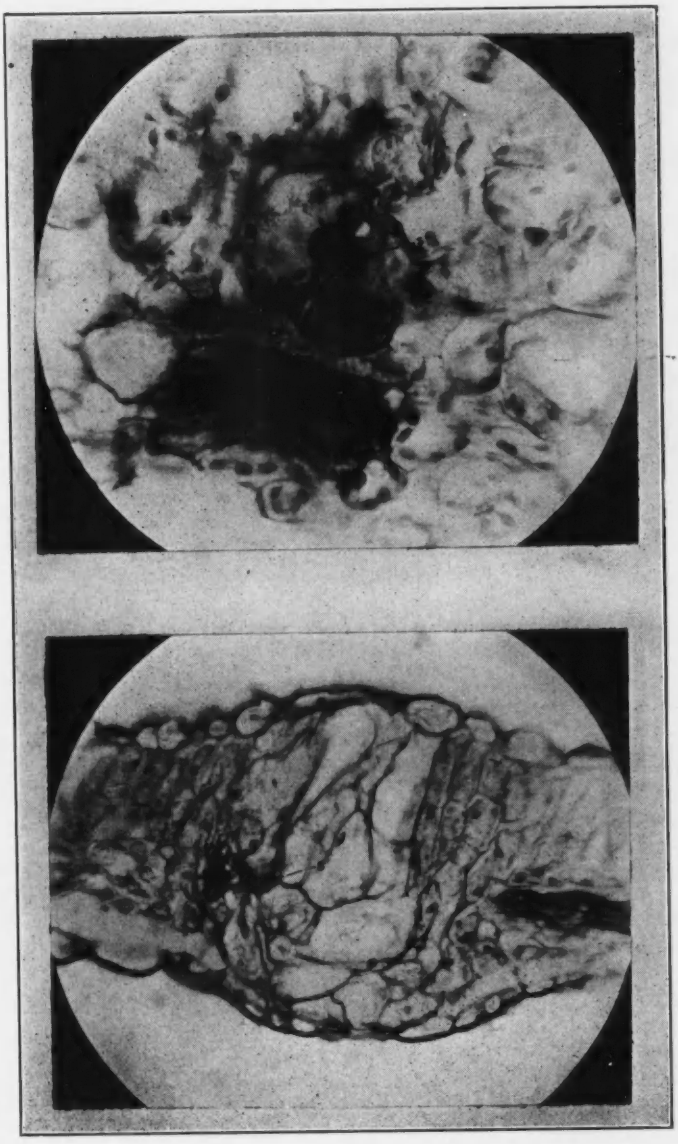
EXPLANATION OF PLATE II

Fig. 3 (Upper). Cross-section of an alfalfa leaflet caged 3 days with *E. fabae*, showing beginning of cell hypertrophy around sheath material (S). × 950.

Fig. 4 (Lower). Cross-section of an alfalfa leaflet caged 3 days with *E. fabae* but killed 9 days after removal of cage and insect, showing hypertrophied cells around sheath (S). × 430.

Injury by Empoasca
J. T. Medler

PLATE II



insects confined to an area, the length of their feeding period and the external symptoms of the tissues at the time leaf sections were killed and fixed for histological work.

If wilted (abnormal) tissues were used in the studies of Smith and Poos, it is probable that their results are not comparable with those found in this investigation. These workers stated (1931, p. 275) that their microscopic preparations showed cells of the phloem which were frequently punctured and torn and distorted or filled partially or completely with red stained sheath material. In none of the preparations of the writer has such an extreme condition been observed. It would be suspected, however, that the feeding habits of a closely confined insect would be much different from those under normal conditions, especially when the actual progression of injury is a slow progression of chlorosis rather than a wilting of leaf tissues.

It seems to be well established that the disorganized state of stem tissues and the loss of normal function of injured cells result in secondary symptoms due to a blocking of plant translocation. Johnson (1934) has proved that comparable symptoms and tissue changes take place in leafhopper-injured and artificially girdled alfalfa. It is conceivable that the appearance of symptoms of injury by *E. fabae* is due to blocking, which is primarily initiated by the leafhopper's feeding. Still, this doesn't explain the fundamental nature of injury caused by the insect.

Smith and Poos (1931, p. 284) believed that injury "is the result of interference with translocation of plant materials which produces wilting when xylem vessels are plugged or yellowing or reddening when the phloem is disorganized and plugged." A careful study of this passage shows they were considering only the ultimate result of the insect's feeding. However, it is seen that no explanation is offered on the fundamental nature of injury, and the reader is left to presume that the nature of injury is a mechanical one, for the authors disclaim any evidence of a toxin.

The fundamental nature of the injury can be more logically explained on the basis of the findings reported in this investigation. These are believed to have dealt with a normal effect of the feeding secretion before secondary conditions entered the picture. It is hypothesized that the injury is primarily caused by a specific compound in the salivary secretion of this insect, which when injected in the plant tissues acts primarily as an agent to induce cell hypertrophy. Over a course of time the action of the material is first seen by characteristic nuclear changes of the cells in the immediate vicinity of the salivary deposit. The cycle of nuclear change involves enlarging of the nucleus, which becomes darkly stained with haematoxylin, and enlarging of the nucleolus, which stains bright red with safranin. Progressive changes of cell hypertrophy then take place in affected cells, which are usually located about vascular bundles and in the immediate vicinity of sheath depositions. It is probable that the "toxic" material is capable of diffusion or conduction along vascular elements and causes cell hypertrophy in the phloem tissue of veins some distance from the feeding puncture.

CONCLUSIONS

A histological study of the feeding punctures of *Aceratagallia sanquinolenta* (Prov.) and *Macrosteles divisus* (Uhl.) shows that these leafhoppers cause no apparent internal injurious effect in alfalfa leaflets. The sheath which is secreted appears to initiate no physiological changes in cells surrounding it, and there are no observable cytoplasmic or nuclear changes which show abnormalities resulting from deposit of this foreign material in the plant tissues.

On the other hand, the nature of plant injury by *Empoasca fabae* (Harris) is unique, and a combination of the insect's feeding habit in vascular tissue and the action of a specific compound injected during its feeding process. This secretion causes hypertrophy in affected cells, and its effect is first characterized by nuclear enlargement and prominent safranin-stained nucleoli. It is conceivable that the hypertrophied cells cause an interruption of translocation processes which initiate secondary external symptoms of chlorosis or reddening in alfalfa leaves.

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Johnson, H. W. 1934. Nature of injury to forage legumes by the potato leafhopper. Jour. Agr. Res. 49: 379–406.

Smith, F. F., and **Poos, F, W.** 1931. The feeding habits of some leafhoppers of the genus *Empoasca*. Jour. Agr. Res. 43: 267–285.

INSECT PESTS IN STORED PRODUCTS, by H. HAYHURST. Pages i-xi and 1-83; 130 photographs of insects by Harry Britten, 5½ x 8¾, cloth. 1940. Published by CHAPMAN AND HALL, LTD., 11 Henrietta St., London, W. C. 2. Price 15 shillings.

This little book is intended for the warehouseman who stores plant and animal products that are susceptible to insect infestation. The primary purpose of the book is to describe the species of insects that may be found in and about different commodities, including some parasites and predators of these pests. Identification is aided by numerous original photographs: 105 of adults, 21 of larvae, and 2 each of eggs and pupae. The distribution and habits of these species are mentioned and particular attention is given to the listing of commodities that they are known to infest. The latter information is brought together in the form of a host index running from page 55 to 79. Finally there is an index of common and scientific names of insects mentioned in the book. We find 107 species listed in this index.

Only 5½ pages are devoted to control of insects infesting warehouses (granaries and mills are not considered). The control measures suggested are limited to sanitary practices. Fumigation is barely mentioned as a last resort for badly infested warehouses.

This is not a must book for American entomologists, but everyone interested in stored products insects should add it to his library.—F. L. C.

TWO NEW SPECIES OF CHIROTHRIPS HALIDAY WITH NOTES ON CHIROTHRIPS FRONTALIS WILLIAMS

(Thysanoptera: Thripidae)

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The two new species of *Chirothrips* Haliday described in this paper and the one figured and discussed (*Chirothrips frontalis* Williams) are unusual in that the lateral length of the praeocular process is at least four-fifths that of the cheek. One of the new species was intercepted by Plant Quarantine inspectors at Washington, D. C., from grass seed imported into the United States from Russia. Owing to their habit of clinging to seed, species of the genus Chirothrips are often transported long distances in such material. It is of some economic significance that, even though several weeks may elapse from the time seed is collected in other countries to the time it is inspected in this country, living specimens are occasionally found upon arrival of the shipments.

Chirothrips praeocularis, new species

Female.—Length about 1.3 mm.

Color.—Fully matured individuals dark brown with orange internal pigmentation in pterothorax; legs almost concolorous with body, all tarsi and inner surfaces of all femora and tibiae lighter; forewings light brownish gray, veins distinctly shaded; antennae with segments I and IV–VIII uniformly dark brown, and II and III distinctly paler.

Structure.—Head (pl. I, fig. 1) with total median length about 1.1 times width across cheeks, and 0.6 as long as pronotum, greatly produced (23μ) laterally in front of eye; vertex with two pairs of small setae just behind antennae and a larger pair situated laterad of the median ocellus nearer the inner margins of the compound eyes, the usual three pairs of minute setae just behind the eyes; cheeks slightly converging posteriorly. Eye approximately half as long as head. Antennae (pl. I, fig. 4) with segments relatively short and stout, about 1.4 as long as head; (greatest width of segment I contained in basal width of head slightly more than 2.8 times); segment II nearly straight on outer surface, its apical angle without a strictly terminal seta, the median length of this segment 30μ, the length of outer surface 36μ, maximum diagonal length 48μ, distance from the tip of projection to pedicel of III 19μ, sense cones on III and IV short, stout, and simple, that on inner

surface of VI small, short. Apex of mouth cone 104μ caudad of occipital margin of head.

Prothorax slightly more than 1.1 times as broad as long and 1.7 times as long as head, with lines of sculpture broken into distinct scallops, setae at posterior angles 36–38μ long. Metascutum with median pair of setae placed well back from anterior margin; metapostnotum slightly less than twice as wide as long (width 95μ, length 50μ). Fore femur with anterior dorsal margin distinctly reflexed, its sculpture conspicuous. Wings slender, nearly straight, the anterior vein of the forewing with 4–3 setae at base and 1–1 beyond, the posterior vein with 4 setae.

Abdomen with distinct lines of sculpture on dorsal surface; subbasal chitinous line on all terga broken into dark dashes or scallops. Sternites II–VI without rounded teeth across middle of posterior margins, but with one or more transverse rows of scallops in front of posterior margin. Segment IX with length of median dorsal pair of setae 115μ, the dorsolaterals 103μ, laterals 106μ; segment X acute, its dorsal length slightly more than basal width (length 100μ, subbasal width 86μ), dorsal setae 148μ, laterals 145μ.

Measurements of female holotype in mm.—Head, total length 0.115, width across eyes 0.100, length from front margin of eye to frontal costa 0.046, lateral length of praeocular process 0.073, least interval between bases of antennae 0.006; prothorax, median length of pronotum 0.188, greatest width 0.218; mesothorax, greatest width 0.260; metathorax, greatest width 0.224; forewing, length 0.863, width at middle 0.050; abdomen, greatest width 0.290.

Total length of antenna 0.188 mm.

Antennal segments	I	II	III	IV	V	VI	VII	VIII
Length (μ)	26	30	26	26	23	26	13	10
Width (μ)	36	.....	30	33	26	20	7	4

Male.—Unknown.

Holotype.—U. S. National Museum No. 54251.

Type locality.—Blackwater Refuge, near Cambridge, Md.

Described from female holotype and 25 female paratypes collected by Dr. H. L. Dozier in seed head of *Spartina cynosuroides* (L.) Roth., August 3, 1939.

Chirothrips praeocularis more closely resembles *C. frontalis* Williams than it does any other species occurring in the Western Hemisphere; in fact, it runs to *frontalis* in the writer's key to the genus (Andre, *1939*). *C. praeocularis* may be distinguished from *C. frontalis*, however, by the much shorter, stockier antenna and by the size of the sense cone on the sixth antennal segment (see pl. I, figs. 1 and 4).

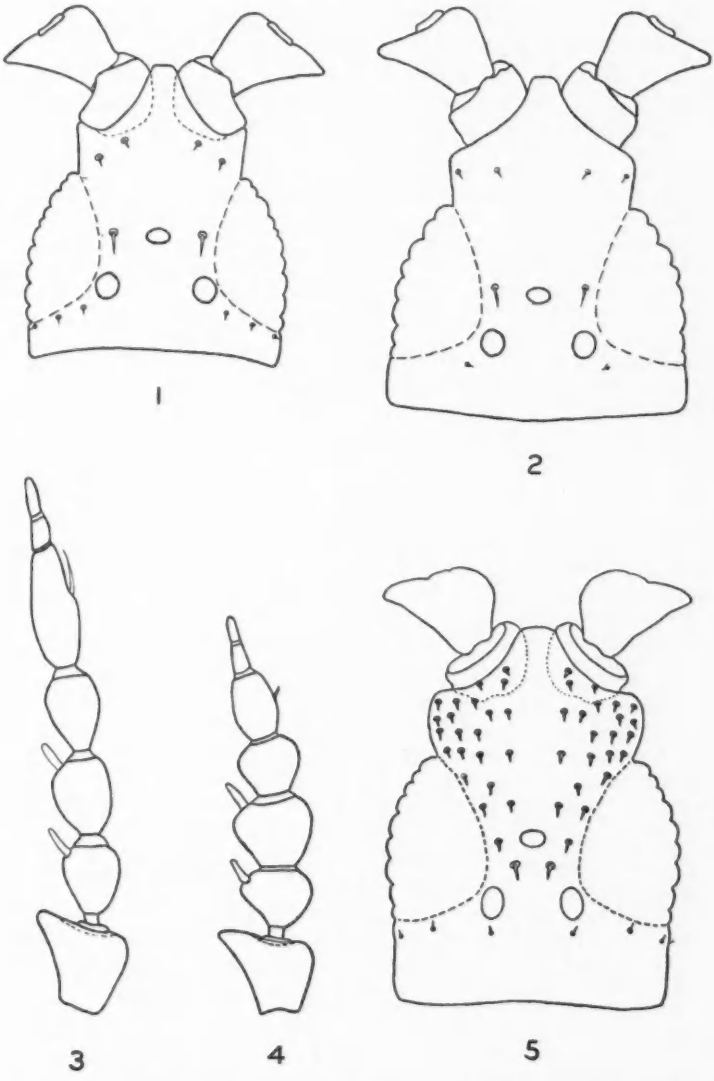

Fig. 1. Head of *Chirothrips praeocularis*, n. sp. 2. Head of *Chirothrips frontalis* Williams. 3. Antenna of *Chirothrips frontalis* Williams. 4. Antenna of *Chirothrips praeocularis*, n. sp. 5. Head of *Chirothrips spinulosis*, n. sp.

Chirothrips spinulosus, new species

Female.—Length about 1.3 mm.

Color.—Mostly dark brown with distal ends of fore tibiae and all tarsi yellowish brown; fore wings rather uniformly gray brown; antenna dark grayish brown with segment III somewhat lighter.

Structure.—Head (pl. I, fig. 5) with its median dorsal length about 1.2 times width across eyes, strongly produced in front, the lateral length of praeocular process about 0.8 that of cheek, sides of this process converging posteriorly, frontal costa wide; vertex with 20 to 24 pairs of short, stout setae, the posterior pair slightly larger than the others and situated behind the median ocellum slightly inside lines tangent to the outer margins of the ocelli, one pair of minute setae close to, and directly behind, posterior ocelli; occiput with the usual three pairs of minute setae behind the eyes; cheeks nearly straight and parallel, slightly less than one-fourth as long as head, continuous with margins of eyes. Eye with dorsal length two-fifths that of head, dorsal width 43μ, dorsal interval 36μ, ventral width 33μ, ventral length 59μ. Each posterior ocellus about 13μ in diamteer, situated 26μ apart and 20μ from median ocellus, which is 8μ in diameter and 66μ from anterior margin of head. Antenna about 1.7 times as long as head (greatest width of segment I contained in basal width of head 3.5 times); II without an evident sense-conelike seta at tip, the median length of this segment 36μ, length of outer surface 50μ, maximum diagonal length 56μ, distance from tip of projection to pedicel of III 26μ, sense cone on III stout and simple, that on IV forked. Mouth cone broadly rounded, its apex 135μ caudad of occipital margin of head.

Prothorax about 1.5 times as long as head and 1.2 times as broad as long; pronotum with sculpturing not pronounced, with numerous prominent, short, stout setae similar to those on head; each posterior angle with two prominent setae about 45μ in length. Pterothorax 1.2 times as wide as prothorax, mesoscutum with about 20 to 25 pairs of stout setae somewhat larger than those on head and pronotum, occupying the median portion and leaving definite bare areas anteriorly and posteriorly; metascutum with 4 to 6 pairs of setae somewhat longer and more slender than those on anterior portion of mesoscutum; metapostnotum with median dorsal length of 50μ and width across middle 128μ. Fore leg with femur not deeply sinuate on outer surface at apex. Fore wing nearly straight, the anterior vein with 4+3 setae in basal portion and 2 or 3 beyond, posterior vein with 4 setae.

Abdomen without prominent sculpture, all tergites lacking dorsal vestiture; lateral portions of posterior margins of terga with conspicuous, sharply-pointed, teethlike thickenings; sterna II–VI with rather prominent thickened scallops segment IX with length of median dorsal pair of setae 99μ, of dorsolaterals 95μ, and of laterals 135μ; segment X elongate, acute, its dorsal length slightly less than one and one-half times basal width (length 92μ, subbasal width 63μ), dorsal setae 115μ, laterals 118μ.

Measurements of female holotype in mm.—Head, median dorsal length 0.155, width across eyes 0.122, greatest width across cheeks 0.112, dis-

tance from anterior margin of eye to frontal costa 0.053, lateral length of praeocular process 0.025, greatest width of head process 0.089, length of cheek 0.030, least interval between bases of antennae 0.007; median length of pronotum 0.231, greatest width 0.280, width across anterior margin 0.138; mesothorax, greatest width 0.356; fore wing, length 1.175, width at middle 0.066; abdomen, greatest width 0.315.

Total length of antenna 0.238 mm.

Antennal segments	I	II	III	IV	V	VI	VII	VIII
Length (μ)	23	33	40	36	30	40	10	13
Width (μ)	35	.....	25	26	23	20	7	4

Male.—Unknown.

Holotype.—U. S. National Museum No. 54252.

Type locality.—Russia.

Described from the following material: Holotype and four female paratypes collected with seed of *Melica ciliata* from Russia, at Washington, D. C., November 2, 1934, by Mr. H. Y. Gouldman (B. P. Q. No. 031644); female paratype from seed of *Isopyrum anemonoides* from Russia, at Washington, D. C., November 3, 1934, by Mr. C. E. Prince, Jr. (B. P. Q. No. 031628).

The nonenlarged first antennal segment, the produced head, and the presence of 20 to 24 pairs of setae on the vertex of the head readily distinguish *spinulosus* from all other described species in the genus.

Chirothrips frontalis Williams

1914. *Chirothrips frontalis* Williams, Entomologist 47: 51–53, fig.

This interesting species was described by Williams (*1914*) from a series of 11 macropterous females collected near Buenos Aires, Argentina, in January, 1913, by Mr. W. O. Backhouse (on a composite locally known as "cepocaballo"). Since the appearance of the original description John (*1922, pp. 347–348*) has compared with it a new species from South Africa, *C. sulcatus*. Moulton in 1933 (*p. 100*) included *frontalis* in a key to the South American species and later (*1936, p. 498*) recorded it from South Africa. Jacot-Guillarmod (*1937, p. 39*) listed *frontalis* in his catalogue of South African Thysanoptera, and it was treated in a synopsis by the present writer in 1939.

Through the kindness of Dr. C. B. Williams the writer has been permitted to study two paratypes of the original series.

The figures of the head and antenna (pl. I, figs. 2 and 3) show *frontalis* to be easily distinguished from all but *sulcatus* John by the position of the posterior pair of setae on approximately the same transverse line as the front margin of the median ocellus, the presence of only two or three pairs of setae slightly posterior to the antennal bases, the lateral length of the praeocular portion of the head, which is at least as long as the cheeks, and the relatively long and slender antennal segments. Although *sulcatus* John (described from a single female collected at Chala, British East Africa) is unknown to the writer, *frontalis* may be separated from it by the lack of "very conspicuous straight longitudinal furrows" on the abdomen mentioned as a character in John's original description of *sulcatus*.

It is hoped that the following notes regarding *frontalis*, which include certain useful characters only recently discovered, will assist in the determination of that species.

Female.—Length about 1.4 mm.

Color.—Dark brown with orange internal pigmentation in pterothorax, distal ends of fore tibiae and all tarsi yellowish brown; wings brownish gray; antenna with segment I dark brown, concolorous with head, II perceptibly lighter than I but darker than III, which is the lightest of all antennal segments, IV–VIII dark gray brown with IV perhaps a trifle the lightest.

Structure.—Head (pl. I, fig. 2) with its median dorsal length 1.1 times greatest width (across cheeks), 0.7 as long as pronotum, lateral projection in front of eye 23μ, vertex with two pairs of minute setae behind antennae, a larger posterior pair situated on or slightly in front of a line through the front margin of the median ocellus, the usual three pairs of minute setae behind eyes; cheeks nearly straight and parallel, about a sixth as long as head. Eye about half as long as head; median ocellus slightly smaller than posterior ones. Antenna 1.4 times as long as head, greatest width of segment I contained in basal width of head about 3.5 times), apex of segment II with a strictly terminal seta, this segment with dorsal length 33μ, greatest diagonal length 49μ, length of outer margin 37μ, distance from apex to pedicel of III 20μ, III and IV each with a stout, simple sense cone, V with a small sense cone on outer surface, that on inner surface of VI not abbreviated. Apex of mouth cone 100μ caudad of occipital margin of head.

Prothorax slightly more than 1.2 times as broad as long and 1.4 times as long as head, with two prominent setae 35–40μ in length at each posterior angle. Metapostnotum about 2.8 times as wide as long (width 112μ, length 43μ). Fore femur with anterior dorsal margin slightly reflexed. Fore wing nearly straight, its anterior vein with 5 to 6 setae at base and 2 near apex, the posterior vein with 4 to 6 scattered setae.

Abdominal sternites II and III with minute rounded teeth along posterior margin, IV to VI with such teeth apparently absent from

middle portion of posterior margin and scarcely visible in lateral portion, posterior margin of VII bare. Segment IX with length of median dorsal pair of setae 83μ, the dorsolaterals 102–112μ, laterals 112–125μ; segment X not elongated, its dorsal length slightly more than greatest subbasal width (length 85μ, subbasal width 78μ), dorsal setae 102μ, laterals 89μ.

Measurements of female paratype in mm.—Head, total length 0.138, width across eyes 0.115, width across cheeks 0.122, length from front margin of eye to frontal costa 0.051, lateral length of praeocular process 0.027, length of cheeks 0.022, greatest width of praeocular process 0.076, least interval between bases of antennae 0.012; prothorax, median length of pronotum 0.198, greatest width 0.256, width across anterior margin 0.134; mesothorax, greatest width 0.300; metathorax, greatest width 0.274; metapostnotum, width across middle 0.112, median length 0.043; fore wing, length 0.780, width at middle 0.051; abdomen, greatest width 0.339.

Total length of antenna 0.231 mm.

Antennal segments.....	I	II	III	IV	V	VI	VII	VIII
Length (μ).....	23	33	33	30	33	43	10	16.5
Width (μ).....	33	.....	24	26	23	17	7	5

Male.—Unknown.

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A REVISION OF THE NEARCTIC HEMEROBIIDAE, BEROTHIDAE, SISYRIDAE, POLYSTOECHOTIDAE AND DILARIDAE (NEUROPTERA), by F. M. CARPENTER. Pages 193–280, of Vol. 74, No. 7, Proceedings Amer. Acad. Arts and Sciences. 1940.

Professor Carpenter is this country's best authority on fossil insects. Such an interest is involved with interest in our fauna's living fossils such as are found in the Neuroptera and related groups. With the available Harvard Collection which now contains the Nathan Banks Collection, Professor Carpenter is in position to give entomology the best possible review of Neuropteroid insects. The volume has text figures of genitalia and plates of wings.—C. H. K.

OBSERVATIONS ON SANDALUS NIGER KNOCH, ITS EGG, AND FIRST INSTAR LARVA[1]

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In 1921, Dr. F. C. Craighead (Proc. Ent. Soc. Wash. 23: 44–46, 1 pl.) made an important contribution to our knowledge of the biology of *Sandalus*. Under the circumstances of his discovery of a pupa of *Sandalus niger* Knoch within the body of a cicada nymph, the parasitic nature of this beetle appears to be definitely established, and, from the larval exuvium which accompanied the pupa, the characters of the mature larva were made known. Prior to this time Dury, 1900 (Jour. Cincinnati Soc. Nat. Hist. 19: 172–173) and Manee, 1908 (Ent. News 19: 288–289) had published observations on the adult beetle. Dury's interpretation of his observations supported the idea of phytophagous habits, but the beetle's parasitic nature was not suspected at this time, and nothing further has been published since Craighead's discovery.

The writer has been fortunate in observing a brood of this beetle and has secured and hatched its eggs. In this paper the writer's observations on the adults, eggs, and first instar larvae are given, and the latter is described and figured. It is hoped that the interest of other entomologists may hereby be aroused, so that the complete life cycle may be made known. This will likely be no easy task, however, for the beetle's life cycle is probably intimately associated with that of its host cicada, whatever species that may be, and the problems that beset a study which involves a subterranean insect with a long life cycle are obvious. One of the first steps in such a study might be the correlation of appearance of broods of the beetle with broods of cicadas, or perhaps someone familiar with the habits and rearing of cicadas may be able to effect parasitism under controlled conditions.

OBSERVATIONS ON THE ADULT BEETLES

Broods.—Observations agree that this beetle occurs in numbers in localized areas, at times appearing to restrict its activities to a certain

[1]The writer expresses his appreciation of the interest that Mr. H. S. Barber and Dr. W. H. Anderson, of the U. S. National Museum, have taken in this paper, and the aid they have rendered.

tree or group of trees. Dury found it associated with ash, Manee with oak, and Blatchley records it from cedar and ash. In the light of its parasitic nature, this apparent association with certain trees has no significance except as it may indicate host or oviposition preferences of the host cicada.

The localized appearance of this insect may be explained in great part by the fact that the female beetle, though winged, has not been observed to fly, so that a great majority of the eggs laid from generation to generation by a given brood are likely laid in the same small area.

In the fall of 1937, a brood of *Sandalus niger* occurred at Columbus, Ohio, on the Ohio State University campus. The beetle was already present in good numbers on September 30, when first noticed. 16 females and 50 males were taken from that date until the last day of October. All beetles except one were taken from a wooded area between the chemistry building and the high school. The single exception was a female found crawling upon the sidewalk at 41 E. Woodruff Avenue, about three blocks away. Occasional males were observed in flight on other parts of the campus, but the brood was very closely confined to this particular woods. Beetles were especially common on trees which stood apart from the others, so that their boles were exposed to the sunlight. They occurred on basswood, beech, elm, sugar maple and sycamore, and were particularly prevalent at a large basswood just behind the chemistry building, standing somewhat apart from the other trees.

This area was re-examined in the fall of 1938 and 1939 for occurrence of the beetle. No beetles were definitely observed, though on two occasions in 1938 what appeared to be a male *Sandalus* was seen in flight about the crowns of trees, but at such a height that positive identification was not possible.

Another brood was encountered October 5 and 6, 1939, by Roy W. Rings, about four miles distant from the 1937 brood, at 1158 Oakland Avenue, Grandview, Ohio. 30 females and 5 males were taken on two afternoons, between the hours of 3:00 and 4:00 P. M., on the trunks of elm and oak, in the back yard of this residence.

Flight.—Though they have not been observed to fly, females appear capable of doing so, and the specimen taken on Woodruff Avenue (October 27) may have flown there from the infestation on the campus. The males, however, are strong fliers, and they are so alert in their flight that it is almost impossible to catch one with the hand. They resemble large bees as they circle about tree trunks in search of females. As the flight of males is closely correlated with mating, further notes may be found under that heading.

Mating.—On October 12, 1937, the writer secured 2 females and 33 males in less than half an hour, during the noon hour, and several other females could have been taken. The day was warm and the sky slightly hazy, and it was to be noted that the males were not as active as they were on bright, clear days, for several were caught in flight by the hand. The locality was re-visited at 3:30 P. M., by which time the sky had clouded over. The males had practically disappeared, a careful search disclosing only two, one still in copulation, the other the prey of

a pentatomid nymph. Of the three females found at this hour, two were ovipositing and the other mating.

Whether mating or ovipositing, the females occur on the trunks of trees, particularly large, isolated trees with boles exposed to the sun. They usually are within reach of the ground, but occur anywhere from the ground level to a height of 12 or 15 feet. On favorable days the males appear in abundance, and are found flying from tree to tree, or circling about the trunks in search of the female. Mating pairs were observed a number of times, but detailed notes on the act of copulation are lacking. It appears at best a lengthy process, and perhaps occurs repeatedly. Other males may be attracted by a mating female, and on one occasion two males were about a mating pair so closely that all four of these large beetles were pinned by the mouth of a cyanide tube seven-eighths inch in diameter. On one occasion a male was observed to alight upon a trunk several feet above a mating pair and slowly run about with its antennae extended, elytra raised and hind wings fanning the air, in its search for the female.

Males were found in abundance and mating only on three days, September 30, October 1, and October 12. Rings captured 5 males and 30 females between the hours of 3:00 and 4:00 P. M. This is just the inverse of the sex ratio of the specimens collected by myself, and with regard to my observations on October 12, it is likely that he would have found the males very numerous if he had collected earlier in the afternoon.

Mating appears to take place only under certain optimum conditions of temperature and light, and possibly humidity and the hour of the day are important. At any rate, the males are abundant and actively searching for their mates at noon or early afternoon of warm, bright, sunny autumn days. Later in the afternoon of the same days the females may still be found, but the males have practically all disappeared.

A table is given, showing the weather conditions for the days that the beetle was found.

Oviposition.—Females not mating were usually ovipositing in the crevices of the bark, anywhere from the ground level to higher than one can reach. There is a possibility that eggs may also be laid in the ground, but oviposition upon the trunks was so commonly observed that this is considered to be the normal habit. Captured females readily laid eggs in the crevices between the cork and the wall of the perforated celluloid vial in which they were kept. The ovipositor can be extended farther than the length of the body, and with whip-like and undulating movements it explores the crevices. Eggs are extruded by pulsating movements of the ovipositor, one at a time in tiny crevices, and four or five at once in larger ones.

Longevity.—This insect appears in the fall of the year; the brood observed by the writer being first seen September 30, but undoubtedly the insects had emerged prior to this date. After a period of unfavorable weather from October 13 to 25, the insect was quite scarce, 6 females and 2 males being taken or seen between October 26 and 31. The life span of any individual, particularly the females, may be expected to last a major portion of this period, though individuals con-

fined in the laboratory did not live more than several days. The beetles have not been observed to feed, and, from Mr. Ring's examination of the alimentary tract, it is highly improbable that they do so.

Weather conditions and activity of the beetle.—Meteorological data for the days the beetle was observed have been supplied by the Columbus weather bureau. Caution must be used in applying such data, as they were taken from the top of the post office building, and will vary somewhat from conditions where the beetle was found. The information is for the hours ending at 1, 2, 3 and 4:00 P. M. The sunshine data covers the duration of sunshine, not the intensity, and the figures are expressed in hours and tenths of hours, i. e., .5 would indicate that the sun shone for 30 minutes of the hour in question.

	Temperature (Fahrenheit)				Sunshine (duration)				Wind Velocity (miles per hour)				Relative Humidity	
Hour (P. M.)	1	2	3	4	1	2	3	4	1	2	3	4	Noon	7:30
(1937)														
Sept. 30	77	80	81	80	1.0	1.0	1.0	1.0	9	9	9	9	42	37
Oct. 1	82	84	85	84	1.0	1.0	1.0	1.0	3	5	5	6	45	42
Oct. 2	77	80	81	79	.0	.3	.2	.1	4	5	5	7	42	76
Oct. 4	69	72	71	70	.0	.4	.0	.0	7	9	11	8	81	83
Oct. 12	71	72	71	58	1.0	1.0	.8	.0	21	24	24	21	41	85
Oct. 26	62	63	61	60	.8	1.0	1.0	1.0	16	21	19	17	47	75
Oct. 27	47	46	46	47	.0	.0	.0	.0	17	19	21	19	82	67
Oct. 29	63	67	70	70	1.0	1.0	1.0	1.0	17	19	19	19	43	49
Oct. 31	54	55	56	57	1.0	1.0	1.0	1.0	9	9	6	7	45	47
(1938)														
Oct. 8	70	73	75	75	1.0	1.0	1.0	1.0	15	18	17	16	41	49
Oct. 9	68	69	71	72	1.0	1.0	1.0	1.0	8	9	9	8	50	40
(1939)														
Oct. 5	77	77	77	78	1.0	1.0	.7	.9	23	23	20	21	41	58
Oct. 6	80	80	81	82	1.0	1.0	1.0	1.0	13	16	14	14	24	42

Abundance of males in flight was observed by the writer on September 30, October 1, and October 12. A single male was observed in flight at 3:00 P. M., October 29, and what appeared to be male *Sandalus* were observed in flight October 8 and 9, 1938, the exact hour not being recorded. As the table shows, these were all sunny days, with temperature approximately 70 degrees or above.

Rings made his collection of the beetle between 3:00 and 4:00 P. M., October 5 and 6, 1939. He reports that they were mating and on the wing at this time.

Males taken when not in flight are as follows: one male resting on a tree trunk near the ground, October 26, 2:30 P. M.; one male crawling in the grass at the base of a tree, October 2, about noon; two males labelled October 4. There are no notes regarding the latter specimens, and the circumstances of their capture are not recalled. They may be erroneously labelled.

Females were observed mating and ovipositing on September 30 and October 1 and 12. Additional data are as follows: one ovipositing on a tree trunk and one in the grass at its base, October 2, about noon;

3 ovipositing, October 26, 2:30 P. M. (this was the first favorable day after a long period of unfavorable weather); one crawling upon the sidewalk, October 27; one upon a tree trunk at arm's reach at 3:00 P. M., October 29; one ovipositing, 1:30 to 2:30 P. M., October 31.

OBSERVATIONS ON THE EGGS

Mr. Rings counted 16,864 eggs in a particularly large and gravid female, and there is a possibility that this specimen had already been ovipositing prior to its capture. These eggs, necessarily minute, are remarkable, not only by the numbers that are produced, but because the time required for hatching requires that the winter is passed as eggs in crevices of the bark of tree trunks, a situation poorly if at all protected from temperature and humidity extremes and fluctuations, desiccating winds, or soaking rains.

The eggs laid by captive females were all stored for a time in a 4-degree C. temperature cabinet, either immediately after deposition or after being held for a month at room temperature and humidity. Some eggs stored at this temperature immediately after deposition were transferred to room temperature and 75% humidity about three weeks later. After about two months incubation, the eggs started to hatch.

A great quantity of eggs, deposited October 12 to 14, was kept, part in a corked, part in an uncorked vial, in a drawer of my desk in room 309, Botany and Zoology Building. The relative humidity of this room is estimated to vary between 15% and 35%. Both sets of eggs appeared plump and viable on November 12, at which time they were transferred to 4° C. On April 25, 1938, eggs from the corked vial were examined. Of 381 eggs, 17 were not viable at this time, having turned a brownish-yellow color, in contrast to the pearly white appearance of the others. From this vial of eggs and on this date, six lots of 50 eggs each were established to incubate at room temperature and relative humidities of 100%, 75%, 70%, 31%, 30%, and 10%.

Hatching was best at 75% and 70% humidity, and these two lots will be considered together. When examined May 15th none had hatched, but the ends were clearing. This transparency at the ends develops prior to hatching. By May 24, six eggs had hatched; May 31, 13 more; when the project was disbanded June 9th, 39 of the hundred eggs had hatched, 37 were still viable, and 24 were dead.

At 100% humidity a fungus developed, and the results were not good. By May 31st two larvae had hatched. On June 9th, 12 eggs were still viable in appearance, but it was impossible to distinguish, among the others, how many had hatched or been killed by fungus.

At 30% and 31% humidities no eggs hatched. By May 15 a number showed an indentation on one side, due to desiccation, and on May 24 all were indented. On June 9, nine eggs from the two lots looked like they might still be viable, the others were all badly shriveled.

The eggs at 10% humidity were all indented May 15th, mostly badly shriveled May 24th, and about half were dry by June 9th.

To summarize hatching where the only definite records are available: eggs deposited October 13 and 14, 1937, were kept until November 12, or for 29 to 30 days, in a corked vial at room temperature. They

were then transferred to a 4° C. temperature cabinet and held until April 25, 1938, or for 170 days. They were then incubated at room temperature and 70% to 75% relative humidity. Hatching was first observed May 24th, 29 days later, and was still in progress June 9th, 45 days later. This gives a total incubation period at room temperature of from 58 to 74 days and over.

The relative humidity in the 4° C. temperature cabinet was 75%. Eggs held in this cabinet until January, 1939, failed to hatch.

OBSERVATIONS ON THE FIRST INSTAR LARVAE

Larvae hatched and kept and 75% relative humidity in the laboratory usually lived not longer than two days. They resemble minute elaterid larvae in body form and activity. At any rate, they are not extremely active, like the first instar larvae of many other insect parasites whose eggs are laid at random and whose first instar larvae must seek out the host. The larvae are not cannibalistic, and pay no attention to each other when closely confined.

The amazing fact is that any of these very small, moderately active and short-lived larvae should survive to find a host nymph. Even if their progress down the tree trunk were aided by dropping to the ground, or being blown to some distance therefrom by the wind, they are still ill-adapted by their legs or mandibles for burrowing through the soil. They may, however, be able to work their way between most soil particles because of their minute size, or follow crevices or dead root paths in the soil, and the environment of the soil atmosphere may favor longer life. Could it be possible that the ultimate host, the cicada nymph, is not the initial source of food?

DESCRIPTION OF THE EGG

The egg is minute, cylindrical, rounded at both ends, .65 mm. long and .14 mm. in diameter, with shell thin but tough, unsculptured. It is pearly white, becoming transparent at both ends prior to hatching.

DESCRIPTION OF THE FIRST INSTAR LARVAE

Body (figs. A and B).—1.06 mm. long, .14 mm. wide (specimen mounted in balsam). Elongate, sparsely setose as illustrated, white. The head is slightly narrower that the body, which is subequal in width until the 8th abdominal segment, thence tapering caudally. Body segments perceptibly decreasing in length from the prothorax to the 1st abdominal segment, thence gradually decreasing or subequal in length to the 8th abdominal segment, 9th abdominal segment as long as the 1st abdominal and 10th and last segment shorter, terminating in a 4-lobed, retractile anal process. A poorly defined sclerite, extending from the anterior margin of the prosternum to the base of the coxae, is present on the prosternum; if similar sclerites exist on the meso- and metasterna they are very poorly defined. Abdominal segments 1 to 9 each with a pair of stout cuticular spines at the anterior third or fourth, near the mid-dorsal line. A seta arises from immediately behind each spine (fig. M).

Head (figs. C and D) longer than broad, widest just before the base, bluntly rounded anteriorly. The ventral mouthparts occupy the entire under side of the head. The nasale is not differentiated and epicranial suture not evident, so that no sutures are visible on the upper surface. What appear to be a pair of ocelli are situated, one behind the other, on each side of the head, midway between the insertion of the antennae and base of head. They appear as red-pigmented spots which are often irregular in outline, or even dispersed.

Antennae (figs. G and H) are located at the sides of head, just behind and above the base of the mandibles. Each consists of a button-shaped base from which arise three appendages or processes. The largest is median, consisting of a basal sclerome and a nipple-shaped, apparently flexible tip. A slender, somewhat shorter and slightly bowed appendage terminating in a seta arises slightly above and in front of the former. The third is a slender spine situated dorsal to the first.

Mandible (fig. J) nearly the form of an equilateral triangle, its base slightly longer than the sides. Inner edge without teeth or molar structure, straight, becoming strongly rounded toward base. Outer edge bearing two setae near base, a broad, transverse notch near apex. Basal margin straight, without evident condyle for articulation, though the mandible is movable. The mandible is one-third as thick, dorso-ventrally as broad at base, and the dorsal face more heavily chitinized than the ventral.

Ventral mouthparts (figs. D, E and F) partially fused, forming a large, rounded plate, trilobed anteriorly, which occupies the entire lower surface of the head. Gular region absent. Mentum and submentum fused to form a somewhat pear-shaped median portion of the plate, defined by lateral sutures extending caudally nearly to the base. The free distal portion may have a limited dorso-ventral movement, and near its tip arise the labial palpi. Each of the latter consists of a single, slightly tapering segment, twice as long as wide at base, cylin-

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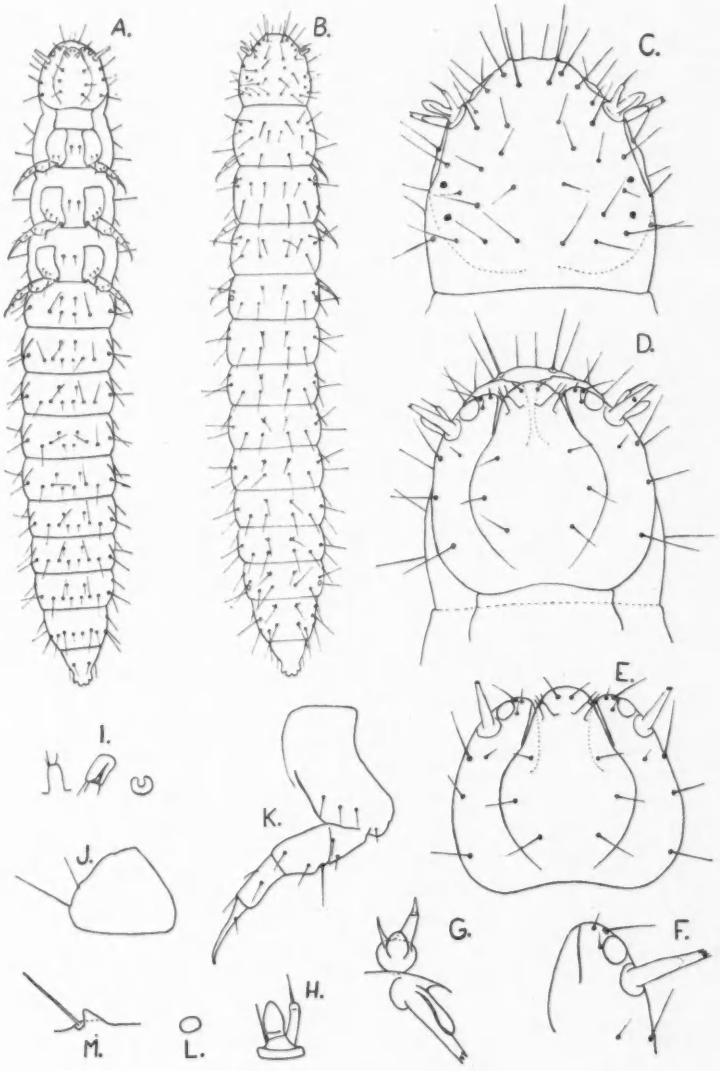
EXPLANATION OF PLATE I

All figures were drawn by aid of a camera lucida and reduced between 4 and 5 diameters in reproduction. A and B are ×120; C, D, E and K, ×400; F to J, L and M, ×600.

Slides from which drawings are made are deposited in the U. S. National Museum

A. Larva ventral view
B. Larva, dorsal view.
C. Head, dorsal view
D. Head, ventral view
E. Ventral mouthparts.
F. Maxillary mala, ventral view.
G. Antenna and maxillary palpus, as seen in lateral view of head.
H. Antenna, ventral view.
I. Labial palpus. Left to right, ventral view, dorsal view showing groove, and sectional view near tip.
J. Right mandible, ventral view.
K. Metathoracic leg, ventral view.
L. Spiracle.
M. Dorsal abdominal spine, with seta arising from behind its base.


A.
B.
C.
D.
E.
F.
G.
H.
I.
J.
K.
L.
M.

drical, with a furrow deepening apically on its dorsal side, and three setae at its apex.

There are no sutures on the maxilla, and it must be quite incapable of lateral movement. Only the distal third, or mala, is defined by its inner margin (fig. E), and is deeply ridged most of its length on its ventral surface, near the inner margin, for reception of the distal, free portion of the labium. The maxillary palpus arises from an oval area near the middle of its lateral margin, and anterior to it is another oval area, distinguishable from the rest of the maxilla only by its periphery.

The maxillary palpus (figs. F and G) is 4 times as long as wide, widest at base and tapering apically, its apex obliquely truncate. The exact nature of the apex is not distinguishable; it seems beset with short setae. An appendage three-fourths the length of the palpus arises near to and above its base and lies closely appressed to its outer surface, which appears to be somewhat excavated for its reception. The latter is club-shaped, with a slender basal portion which is best observed in lateral view (fig. G).

The ventral mouthparts are sparsely setose, as shown in fig. E.

Spiracles (figs. L and B) are oval, simple. Three pair located on the tergites, close to the lateral margin, of the mesothorax and abdominal segments 1 and 8. The former is at the anterior fourth of the segment, the latter two just behind the middle.

Legs (fig. K) 5-segmented, terminating in a single, slender claw, curved apically.

SUMMARY

The present paper contributes several details to our knowledge of the life history and habits of *Sandalus niger* Knoch, namely, description and figures of the first instar larva, and rather extensive notes on the adults and eggs. Previous to this time briefer observations on the adults were published by Dury, 1900, and Manee, 1908, and Craighead's (1920) discovery of a parasitized cicada nymph is indicative of its parasitic nature, and has made known the characters of the last instar larva.

The complete life cycle of this remarkable insect is far from understood, and one would do well to distinguish fact from fancy in this contribution. However, with our present knowledge it is probable that *Sandalus* has a hypermetabolic life cycle as complicated as that of the Meloidae or Rhipiphoridae. The first instar larva differs radically from the last instar larva in nearly every detail, and Dr. Anderson indicates that it is unusual, among the coleoptera, to find abdominal spiracles on the first and eighth segments only.

EXPERIMENTS ON THE NITROGEN ECONOMY OF TERMITES

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Hardly less intriguing than the questions pertaining to the carbohydrate metabolism of termites are those concerned with the utilization of nitrogen. As Uvarov (1928) stated in reviewing the literature on the metabolism of wood-eating insects, "The most difficult problem is not the digestion of cellulose, but how to discover the means by which the deficient nitrogen is obtained."

The nitrogen economy of termites was emphasized by Cleveland (1925) when he found that termites grew as well on filter paper as on wood. Cook and Scott (1933) carried out feeding experiments with mixtures of proteins, carbohydrates, fats, and vitamins and concluded that the nutritional requirements of termites were comparable to those of other animals. Their experiments, however, did not give any clue to the source of the necessary foods in nature. Roessler (1932) and Hendee (1935) found growth on filter paper less satisfactory than on wood although on neither substrate was there an increase in the total weight of the group of termites. Roessler found that sound wood was more suitable than decayed wood whereas Hendee observed the reverse. In their experiments cannibalism was common in group cultures and when isolation of individuals was practiced the mortality was high from other causes. Hendee obtained significant increases in nitrogen content of surviving isolated termites and of the survivors in group cultures but was unable to obtain an increase in nitrogen of the group as a whole. In her experiments ranging up to 112 days in duration the mortality of group cultures was about 55 per cent. In spite of the difficulties due to cannibalism she could show that fungi play an important role in the termite colonies and has suggested that they detoxify harmful materials in the wood or serve as a source of food.

During investigations by the author on the carbohydrate nutrition of *Zootermopsis* a number of cultures were started. Initially these were uniformly unsuccessful, resembling those

TABLE I. GENERAL COMPARISON OF TWELVE TERMITE CULTURES OF ZOOTERMOPSIS

No. of Exper.	Duration	Termites at Beginning			Termites at End			Wood at Beginning		Wood at End		Pellets at End		Total N	
		Number and Kind	Wt.	Total N Content	Number and Kind	Wt.	Total N Content	Dry Wt.	Percent N	Dry Wt.	Percent N	Dry Wt.	Percent N	Begin.	End
			mg.	mg.		mg.	mg.	gm.				gm.		mg.	mg.
1	18 mos...	10 9th inst.... 1 sold.nymph 5 4th inst.	600 (wet)	12.0	3 orig. ind..... 2 young Remains of 6 dead term.	175.6 (wet)	4.1	7.782	0.036	all eaten	.....	3.136	0.270	14.8	12.6
2	18 mos....	10 9th inst. 1 sold.nymph 5 4th inst.	593	11.9	6 orig. ind. 19 young	426.5	8.4	7.035	0.036	Wood mostly eaten, remainder included with pellets		3.539	0.220	14.4	16.2
3	18 mos....	10 9th inst. 1 sold.nymph 5 4th inst.	595	11.9	5 orig. ind. 5 young 2 dead	242.5	5.1	6.636	0.036	Included with pellets		3.189	0.261	14.3	13.4
4	18 mos....	10 9th inst. 1 sold.nymph 5 4th inst.	563	11.3	7 orig. ind. 21 young	466	7.2	8,984	0.036	2.288 gm.	0.046	2.895	0.237	14.5	15.2
5	97 days..	3 5th inst.	62.5 (wet)	1.46	All alive	83.6 (wet)	1.40	0.790	0.053	0.514	0.041	0.149	0.178	1.88	1.88
6	97 days..	3 5th inst.	57.1	1.33	All alive.....	81.2	1.25	0.707	0.053	0.423	0.029	0.166	0.146	1.70	1.61
7	25 mos....	About 20 nymphs	161 (dry)	14.7	13 orig. of which 1 was a soldier 60 new 5th inst. 7 2nd-3rd inst.	197 (dry)	16.0	180	0.040	162	0.039	7.2	0.142	86.7	89.2
8	25 mos....	About 20 nymphs	108	9.8	10 orig. ind. 1 soldier 38 4th-6th inst. 9 1st-3rd inst.	140	11.1	259	0.055	242.5	0.053	2.257	0.261	151.8	146.0
9	25 mos....	Pr. alates	17 (dry)	2.5	Orig. pair, 4 soldiers 109 nymphs	311 (dry)	22.7	1161	0.037	1115	0.038	Included with wood		432.1	446.4
10	9½ mos..	Pr. alates	17	2.5	Orig. pair 1 soldier	39.2	3.1	not weighed	0.053	not weighed	0.045	.....	0.085	.....	.....
11	8½ mos..	Pr. alates	13	1.34	Orig. pair, 1 soldier 14 nymphs	23.4	2.08	15.9	0.054	13.3	0.055	1.11	0.106	9.93	10.57
12	10½ mos	Pr. alates	17	2.44	Orig. pair, 7 nymphs	32	2.35	202.0	0.053	197.4	.....	0.525	.....	.....	.....

reported by Hendee and Roessler in which cannibalism was excessive and no increase in weight and number was obtained. Some factor or factors in the laboratory cultures did not fulfill the growth requirements. Since nitrogen in some fixed form is so uniformly necessary to animals and since it is present in relatively small quantities in wood it seemed that information on the amount of nitrogen in the food of the termites and in the termites themselves might explain the difficulties encountered in laboratory cultures and provide a clue to the factors that were of importance in nature. The possibility of nitrogen fixation in termite colonies was considered and in most experiments data necessary for preparing a nitrogen balance were obtained.

I. Experiments on *Zootermopsis*

A. Nitrogen balance for laboratory colonies containing wood as the only substrate

Cultures were started with weighed amounts of termites and wood, samples of which were analyzed for nitrogen. Monterey pine, *Pinus radiata*, was used unless otherwise indicated. The wood was well moistened and was enclosed in a suitable container with a close-fitting but not air-tight cover. With this arrangement the cultures maintained saturated humidity without the addition of water during the experiment. No attempt was made to control the temperature which ranged from 15 to 28 degrees C. The data for these cultures are given in Table I.

Discussion of Table I

Experiments 1–4 show results quite comparable to those obtained by Hendee and Roessler. There is a decrease in total nitrogen even though in two of the colonies there was an increase in number of individuals. Experiments 5 and 6 were selected as the best out of a total of 30 similar experiments, each involving 3 individuals. They were the cultures in which the greatest increase in wet weight was observed. Of the other 28 cultures 3 termites survived in 9 of them but showed less gain in wet weight than in experiments 5 and 6. Two termites survived in 6 cultures and 1 termite in 1 culture. All were dead in the rest.

In experiments 5 and 6 the original termites showed an increase of about 35 per cent in wet weight. This might be interpreted as growth. When the nitrogen content was examined, however, it was found that there was a decrease in nitrogen rather than a gain. Since the nitrogen decreased in these two most successful cultures it is probable that a similar or greater decrease occurred in the others of the 30.

Experiments 5 and 6 emphasize the inadequacy of weight increase as a measure of nitrogen assimilation. This is again seen in experiment 10 where the final dry weight of the termites was 2.3 times the initial dry weight but the final nitrogen content was only 1.24 times the original

nitrogen. Experiment 9 shows an increase of 18.3 times in dry weight but only 9.1 times in nitrogen content. Experiment 12 shows a decrease in total nitrogen whereas the dry weight almost doubled. In this experiment the original alates produced 7 young, two of them in the 4th instar and the others younger, yet the amount of nitrogen in parents plus offspring was no greater than that in the original pair. Without data on nitrogen content such a culture would be assumed to be undergoing a true assimilation of this substance, whereas actually this is not the case. Even increase in numbers is not a sure sign of nitrogen assimilation.

A chief feature of these cultures is the general failure to obtain increases in nitrogen. The greatest increase was found in experiment 9 in which decayed wood from a down log was used. In the log were a few wood-boring coleopterous larvae. It is possible that some were included in the block used as the substrate and that the termites used them as food. However, it is perhaps significant that more wood was used in this experiment than in any of the others and that the wood was decayed.

In general the results of Table I fail to demonstrate any significant fixation of atmospheric nitrogen. The determination of the nitrogen involved an error of about 5 per cent and in most cases the nitrogen contents of the cultures at beginning and end do not differ by more than this amount. The termites appear to be unable to assimilate much nitrogen from Monterey pine wood containing .036–.055 per cent nitrogen. It should be noted that use of a pair of alates in starting experiments 9–12 avoided the difficulty of cannibalism so prevalent in the other cultures. When possible, alates were used in subsequent experiments.

B. AMOUNTS OF NITROGEN IN NATURAL COLONIES

According to Heath (1927) a pair of alates in nature usually produces about 40 young after two years. This is a larger number than was observed in most of the laboratory experiments. In order to determine whether the greater success of natural colonies is correlated with the presence of larger amounts of nitrogen some wood and pellets were obtained from a colony of *Zootermopsis* occupying the base of a stump. These were analyzed for nitrogen and values of 0.18 per cent for the wood and 0.25 per cent for the pellets were obtained. Since the cellulose of the wood is largely digested during passage through the termite the larger percentage of nitrogen in the pellets does not necessarily indicate an increase in absolute amount but may be accounted for by a decrease in the other constituents. If it be assumed that the lignin in the wood is unaffected during passage through the termite the amount of this material in the pellets can be used to estimate the wood eaten, provided the lignin content of the wood is also known. Knowing the amount of wood used to form the pellets a change in the absolute amount of nitrogen can be detected.

Analyses of wood and pellets of this colony have already been reported (Hungate, 1936). The resistant lignin amounted to 28.4 per

cent of the wood and 37.7 per cent of the pellets. If none of the lignin was digested and if there was no gain or loss in nitrogen, the wood with a nitrogen content of 0.18 per cent should give pellets containing 0.24 per cent nitrogen. Actually there is some digestion of lignin during passage of wood through the termite as is indicated by the data for the following laboratory colony in which all the wood was consumed (Table II).

It is apparent that in this culture only 82.5 per cent of the original lignin was present in the pellets. If it be assumed that the lignin was decomposed to the same extent in the stump colony, the amount of nitrogen to be expected in the pellets would be $\frac{37.7 \times 0.18}{28.4 \times 0.823} = 0.29$ per cent. This is a little greater than the nitrogen found, indicating that some had been assimilated during passage through the termite. These data alone do not provide any information about possible fixation of atmospheric nitrogen since it is conceivable that the nitrogen assimilated might exceed that fixed.

TABLE II. COMPOSITION OF WOOD AND PELLETS

	Initial Wood	Pellets from Wood	Difference
Soluble in 2-percent NaOH	1.938 gm.	1.098 gm.	−0.840 gm.
Soluble in 72-percent H_2SO_4	4.210	0.690	−3.520
Residue, lignin	1.634	1.348	−0.286

The most striking feature about the wood of this natural colony is the large percentage of nitrogen found. Whereas the woods used as food in the laboratory cultures contained from 0.035–0.055 per cent nitrogen the wood in this colony showed 0.18 per cent.

In order to obtain more information on the nitrogen content of natural colonies a number of samples of sound wood were collected and also wood from flourishing natural colonies of termites. These samples were analyzed for nitrogen and the specific gravity was determined. It was assumed that the uneaten portion of the wood did not undergo significant changes in volume during the time the termites were living in it. Wood that was too rotten to hold its shape was not collected. The sound wood was separated into sapwood and heartwood before the determinations were made. It was not possible to detect the line between sapwood and heartwood in the termite-infested logs, but since most of the wood samples were taken from rather deep within the log it is probable that they were principally heartwood.

The results are summarized in Table III.

A significant feature of these data is the greater amount of nitrogen per gram in the termite-infested wood. Apparently the wood eaten by termites in nature often contains a considerably larger amount than that used in the laboratory cultures. There are several possible ways in

which one might account for such additional nitrogen per unit weight. It might be added fixed atmospheric nitrogen; it might be nitrogen coming into the wood from the closely adjacent soil; or it might result merely from the decomposition of non-nitrogenous materials in the wood by fungi. The importance of this last mechanism can be evaluated by using the data on specific gravity and nitrogen content per cubic centimeter in Table III. The decreased average specific gravity of the termite wood as compared with both the sound sapwood and heartwood indicates decomposition of the wood amounting to 15–20 per cent of the original weight. In measuring the specific gravity of the termite woods alcohol was used as the liquid to be displaced. This readily entered the burrows (the method is described in more detail in another paper, Hungate, 1940). Thus the specific gravity of the uneaten wood was obtained. Since it has often been observed that the termites eat by

TABLE III. SUMMARY OF SPECIFIC GRAVITIES AND NITROGEN CONTENTS OF SOUND AND TERMITE-INFESTED MONTEREY PINE

	Sound		Termite Infested
	Sapwood	Heartwood	
Number of Samples	19	20	12
Av. mg. N per gm	0.477 ± 0.011	0.354 ± 0.009	0.696 ± 0.044
Range	0.31 — 0.63	0.28 — 0.48	0.40 — 1.19
Av. s. g. in gm/cc	0.532 ± 0.007	0.482 ± 0.006	0.411 ± 0.014
Range	0.43 — 0.63	0.42 — 0.57	0.26 — 0.50
Av. mg. N per cc	0.253 ± 0.006	0.170 ± 0.004	0.266 ± 0.013
Range	0.16 — 0.32	0.14 — 0.23	0.16 — 0.44

preference the softer and lighter wood between the annual rings and since in some of the samples large amounts of this wood had been eaten, it is possible that the measured specific gravities of the termite-infested woods are somewhat higher than would have been found if the wood consumed by the termites had still been present. In other words fungus action may have caused slightly more decomposition than would be calculated from the observed specific gravities.

The increased percentage of nitrogen in the wood of the termite colonies can in part be accounted for by this action of the fungi. But reference to the data on milligrams of nitrogen per cubic centimeter in which allowance has been made for the action of the fungi shows that the nitrogen content per unit volume of termite wood is slightly greater than in the sapwood and markedly greater than in the heartwood. Since most of the analyzed termite wood was heartwood it is evident that there was an increase in the absolute amount of nitrogen. Since the experiments of Table I gave little evidence of nitrogen fixation the soil was considered as a possible source of this added nitrogen.

C. EXPERIMENTS USING SOUND HEARTWOOD AND SAPWOOD WITH SOIL

Weighed quantities of sandy soil and freshly cut heartwood of Monterey pine were introduced into a gallon mayonnaise jar. A second jar was supplied with similar soil but received freshly cut sapwood. Samples of soil, heartwood and sapwood similar to those used in the experiment were weighed and set aside for later analysis. Additional moisture was placed in the soil in both cultures, and they were supplied with a pair of *Z. angusticollis* alates on August 8, 1934. The lids were loosely screwed on the culture jars and the latter were half buried in moist soil in a lath house on the Stanford University campus. A box over them excluded light. On October 10, 1934, examination showed that the alates had died. Death was probably due to toxic materials in the recently cut wood. The dead alates were removed and replaced with a pair of alates of *Z. nevadensis*. The cultures were moved to the basement of the laboratory and left undisturbed until August 8, 1935.

TABLE IV. GRAVIMETRIC DATA FOR HEARTWOOD CULTURE

	Beginning	End	Difference
Wt. wood	675 gm.	524 gm.	—151 gm.
Wt. soil	596	582	— 14

At that time the wood in each culture was split open. No termites were found in the heartwood culture so a new pair of *Z. nevadensis* alates was added. The culture with the sapwood was found to contain numerous termites including at least two large soldiers. In each culture the fresh faces of the split wood were replaced in close juxtaposition. The culture jar without the lid was placed in a battery jar containing one-half per cent H_2SO_4 in the base and covered with a glass plate. The cultures were placed in a dark closet in the laboratory and left undisturbed until the end of the experiment.

On September 9, 1936, thirteen months after the 3rd pair of alates had been added, the heartwood culture was found to contain the original pair, one small soldier, and six nymphs. The wood in the culture was rotten at the base and rhizomorphs of a fungus were visible upon and within both wood and soil. The termites, wood, and soil were removed, dried, and weighed. The initial and final weights of soil and wood are shown in Table IV.

The wood was divided into three parts approximately equal in volume. One of these included the basal wood in contact with the soil; another included the top portion most distant from the soil; the other was intermediate. The percentages of nitrogen in these three pieces of wood, in the original wood, in the soil of the beginning, and in the soil at the end were determined. These data have been collected in Table V.

During the experiment there was a decrease in the percentage of nitrogen in the soil and an increase in the percentage in the wood, the

greatest increase being in the wood in contact with the soil. The average percentage of nitrogen in the wood was obtained by multiplying each percentage by the weight of that fraction, adding and dividing by the total weight. A value of .077 per cent N was obtained. The nitrogen in the termites and in the mixed soil and pellets was determined. A nitrogen balance as indicated in Table VI was then set up.

Several features of the culture are of interest. The percentage of nitrogen in the wood increased from 0.030 to 0.077 and the absolute amount of nitrogen in the wood about doubled. Apparently the fungi increased the concentration of nitrogen in the wood, not only by decomposing the carbohydrate constituents but also by bringing in nitrogen

TABLE V. PERCENTAGES OF NITROGEN IN MATERIALS OF THE HEARTWOOD CULTURE

	Beginning		End	
Sample	1	2	1	2
Soil	0.125	0.126	0.096	0.097
Wood	0.031	0.030	.....	.....
Basal one-third of wood	.....	.....	0.149	0.146
Middle one-third of wood	.....	.....	0.067	0.065
Top one-third of wood	.....	.....	0.059	0.060

TABLE VI. NITROGEN BALANCE FOR THE HEARTWOOD CULTURE

	Beginning	End
Total N in wood	0.2093 gm.	0.4011 gm.
Total N in soil	0.7450	0.5595
Total N in termites	0.0013	0.0020
Total N in mixed soil and pellets	.....	0.0024
Total	0.9556	0.9650

from the soil. This increase is most marked in the wood nearest the soil and rapidly falls off in the more distant portions. The percentage of nitrogen in the basal part of the wood approaches that of the natural colony mentioned earlier. There is no indication of fixation of atmospheric nitrogen.

Twenty-three months after addition of the *Z. nevadensis* alates to the sapwood culture examination showed that a considerable development had taken place. The dilute solution of the H_2SO_4 in the base of the battery jar contained the bodies of eighty-three termites which had evidently fallen over the side of the culture jar. Most of them appeared to be in the 6th or 7th instar. The wood of the culture was traversed by many burrows, principally in the region near the soil but also extending to the top. In the basal part of the wood were found the original pair, eight large soldiers, and eighty-four other termites. This portion of the wood was extremely rotten, and white mycelial

strands extended through the soil and into the wood. On top of the wood was a mat of fungus mycelium.

The termites were removed, dried, and weighed and so were the pellets which were stuck on the wood and on the sides of the container. Some pellets were mixed with the soil immediately beneath the wood. All of this soil which contained pellets was separated, dried, and weighed and the remaining soil was similarly treated. The weights obtained and the calculated dry weights of the soil, wood and termites present at the beginning of the experiment are given in Table VII.

Since the number of termites that had drowned in the battery jar used to maintain humidity was about equal to the number alive in the

TABLE VII. GRAVIMETRIC DATA FOR THE SAPWOOD CULTURE

	Beginning	End	Difference
Dry weight of soil	610 gm.	484 gm.	—126 gm.
Dry weight of wood	953	565	—388
Dry weight of termites	0.013	0.293 0.586 est.	+0.573 gm.
Dry weight of pellets		7.890	
Dry weight of mixed pellets and soil		3.868	

TABLE VIII. PERCENTAGES OF NITROGEN IN THE MATERIALS OF THE SAPWOOD CULTURE

	Beginning		End	
Sample Number	1	2	1	2
Percentage N in soil	0.125	0.126	0.080	0.080
Percentage N in wood	0.049	0.050	0.087	0.090
Percentage N in pellets			0.351	0.356
Percentage N in mixed soil and pellets			0.268	0.275
Percentage N in termites	9.9		7.89	7.36

culture at the end of the experiment and since they seemed to be somewhat larger, it was assumed that in weight and nitrogen content they were at least equivalent to the living termites. With this estimate the dry weight of the termites increased by about forty-five times.

Unfortunately in this experiment there was a loss of soil or an error in weighing and the discrepancy between the 484 gm. of soil at the end and the 610 at the beginning cannot be explained. For this reason the experiment cannot be used to set up a nitrogen balance and it is not possible to prove conclusively that growth of the termites occurred without nitrogen fixation. However, of the valid data obtained none point toward nitrogen fixation. The percentages of nitrogen in the various parts of the sapwood culture appear reliable and from these some information can be gained. The analytical data are given in Table VIII.

The data of Table VIII show that the percentage of nitrogen in the wood almost doubled during the experiment while the nitrogen content of the soil materially decreased. It is also evident that the nitrogen content of the pellets is considerably above that of the wood.

As indicated in Table VII, 7.89 gm. of pellets and 3.868 gm. of mixed soil and pellets were recovered. If it be assumed that both pellets and soil in the soil-pellet mixture had the same nitrogen content as that found where they occurred separately the weight of pellets in the mixture can be calculated by the formula,

$$X \text{ (percentage N in separated pellets)} + (1\text{-}X) \text{ (percentage N in soil)} = \text{percentage N in mixed soil and pellets,}$$

in which X is the pellet fraction of the mixture. A value of 2.704 gm. for the weight of pellets is obtained. This gives a total of 10.594 gm. of pellets formed. In experiments 5 and 6 of Table I which were of short duration and in which there were no indications of mold growth the weight of pellets recovered was about 55 per cent of the wood eaten. In other experiments values between 40 and 60 per cent have been obtained. Assuming that the ratio between wood eaten and pellets formed was the same in the sapwood experiment as in these other cultures, the weight of wood eaten can be calculated and is found to be about 21.0 gm. According to the amount of nitrogen in the pellets (38.4 mg.) and the increase in the termites (43.5 mg.) the wood eaten must have contained 81.9 mg. of nitrogen. On the basis of 21.0 gm. total weight this consumed wood must have had an average nitrogen content of 0.39 per cent, a value much greater than that for the original wood (0.05 per cent). Furthermore it would appear that over 50 per cent of the consumed nitrogen had been assimilated.

The data on the percentage of nitrogen in the sapwood at the beginning and at the end of the experiment show that there was a considerable increase in the percentage of nitrogen in the wood, from 0.050 to 0.089. This latter value is below 0.39 per cent, the calculated nitrogen content of the wood eaten by the termites. However, a higher nitrogen content of the wood in close proximity to the soil was observed in the heartwood culture, Table V, and might also be expected in the sapwood experiment. The wood which showed the most termite burrows was the basal portion in the immediate vicinity of the soil and this was also structurally weakest due to fungus action.

In the heartwood culture the basal one-third of the wood contained five times as much nitrogen as the original wood. Since in the sapwood culture the fungi were even more active, as shown by the greater weight of wood decomposed, it is not unreasonable to suppose that the ratio between final and initial nitrogen would be greater and a ratio of eight seems quite possible. Thus the calculated value of 0.39 per cent as the nitrogen content of the wood eaten by the termites is in fair agreement with the nitrogen content that we might expect when a gradient of nitrogen comparable to that observed in the heartwood culture is taken into account. From these experiments it appears that the nitrogen used for the growth of the termites may be brought into the wood by fungi, presumably as a part of the fungus body.

D. FURTHER EXPERIMENTS WITH AND WITHOUT SOIL

Since in the preceding sapwood culture there was the unfortunate discrepancy between the original weight of the soil and its weight at the end it seemed desirable to conduct further cultures along similar lines to be sure that atmospheric nitrogen was not in some way concerned with the growth of the termites. It was also desired to test further the possibility that with a large amount of wood the accumulation of wood nitrogen by the fungi might support the growth of the termites, in which case soil would not be necessary.

It was thought that the soil in these experiments might affect the cultures not only as a source of nitrogen but also as a source of wood-decomposing fungi. In order to separate these two possible effects some cultures received only a small amount of soil, 10 gm., whereas the rest received 600 gm. or more. It was hoped that the small amount added to the controls would serve to inoculate with fungi but would not supply a significant amount of nitrogen. The soil in the control cultures was disregarded when the cultures were analyzed at the end of the experiment since the small amount was difficult to collect quantitatively and the change in nitrogen in it was probably not large since its total nitrogen content was only 9 mg.

All these cultures, except 187 and 188, were started with two pairs of alates of *Z. nevadensis* with a dry weight of 45 mg. and a nitrogen content of 2.45 mg. The data have been collected in Table IX.

In only one culture, No. 196, was significant growth obtained. When data for this culture are compared with the others it is seen that the principal point of difference is the large increase of nitrogen in the wood and the decrease in the soil. Since the wood decreased in weight by about one-fifth during the experiment, fungi must have been active and to them the transport of nitrogen can be ascribed. In many of the cultures there was a definite loss in weight of the wood during the experiment, presumably due to fungi. But the fungi in the cultures with no termite growth did not in most cases cause much increase of nitrogen in the wood. It thus appears that fungus attack in itself is not necessarily favorable to the termites but rather certain kinds of fungus attack. This leads to the hypothesis that different kinds of fungi are concerned and that some in their action are more favorable to the termites than are others. Cultures 199 and 200 showed some transfer of nitrogen into the wood and No. 199 gave some indications of termite growth, but in neither of these does the amount of nitrogen accumulated from the soil compare with that in 196.

Another feature in Table IX is the fact that the wood of certain logs appeared to be distinctly unfavorable to termite growth, the most notable example being experiments 185–188. Whether the failure of these experiments was due to toxic materials in the wood or to other unfavorable factors could not be determined. Cultures 187 and 188 differed from the rest in that nymphs of *Kalotermes minor* rather than alates of *Z. nevadensis* were used.

Finally, the results show no evidence of nitrogen fixation. Considering the errors involved in estimating the weight and nitrogen content

TABLE IX. NITROGEN BALANCES FOR TERMITE CULTURES WITH SOIL ADDED

Expt. No.	Duration	Observations on Fungus Attack	Termites			Wood at Beginning		Wood at End Pellets Included		Soil		Total N	
			No. at End	Wt.	Total N	Wt.	Total N	Wt.	Total N	Total N Beginning	Total N End	Begin.	End
				mg.	mg.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
183	23½ mos.	No attack	0			492	0.197	513	0.205	Control		0.199	0.205
184	"	Basal wood attacked	3 orig.	57	5.1	575	0.408	465	0.396	0.528	0.590	0.938	0.991
185	"	No attack	0			710	0.225	663	0.236	Control		0.227	0.236
186	"	Fungi on surface	0			655	0.220	526	0.259	0.528	0.538	0.750	0.797
187	"	Dense felty fungus on wood	0			640	0.215	604	0.202	Control		0.217	0.202
188	"	Slight attack	0			689	0.233	599	0.269	0.528	0.520	0.763	0.789
189	"	Some attack	2 orig. 1 young	38	2.7	612	0.233	591	0.189	Control		0.235	0.192
190	"	Slight attack	3 orig. 1 young	46	4.2	643	0.272	526	0.238	0.528	0.516	0.802	0.758
191	"	Thick fungus mat on wood	1 orig.	13	1.5	661	0.237	593	0.212	Control		0.239	0.214
192	"	No fungi apparent	0			635	0.218	538	0.246	0.528	0.504	0.748	0.750
197	"	No evident attack	2 orig. 3 young	36	3.7	730	0.266	633	0.271	Control		0.268	0.275
199	"	Sapwood attacked	3 orig. 7 young	41	3.9	733	0.251	603	0.291	0.528	0.491	0.781	0.786
200	"	Sapwood slightly attacked	2 orig. 2 young	28	2.9	703	0.272	605	0.324	0.528	0.446	0.802	0.773
196	36 mo.	Dense fungus growth on top and indications of fruiting body formation	2 orig. 7 soldiers 247 young	592	51.0	5065	1.550	4023	2.001	1.228	0.832	2.780	2.884
195	"	No attack	0			5230		not analyzed		Control	Sum	9.749	9.852

The brackets enclose experiments in which wood from the same log was used.

of the original wood and that the method of nitrogen analysis involved a five per cent error the agreement between original and final nitrogen is satisfactory in most of the experiments.

The difference between the initial and final total nitrogen content of the culture 196 was + 104 mg. This is 3.7 per cent of the total nitrogen and 55 mg. more than the nitrogen increase in the termites. But with a 5 per cent error in analysis it cannot be regarded as significant, particularly since the data for some of the unsuccessful cultures show as great a proportional increase in nitrogen. The large amount of wood used in this experiment involved an error so large that the exact source of the nitrogen used in growth could not be demonstrated. It was possible to use less wood in proportion to termites when *Kalotermes* was studied and it could be shown that the nitrogen increase in the termites occurs at the expense of the nitrogen in the wood, with no fixation from the atmosphere.

E. CULTURE EXPERIMENTS USING WOOD WITH ADDITIONAL NITROGEN

The evidence thus far presented points toward available fixed nitrogen as a limiting factor in the growth of *Zootermopsis*. If this interpretation is correct it should be possible to improve growth in laboratory cultures by the addition of nitrogen.

This possibility was tested as follows: A dealated pair of *Z. nevadensis* was placed with 20 gms. of air-dried sawdust (oven dry weight 18.5 gms.) in each of five bottles containing, respectively, the following additions: (1) 40 cc. distilled water, (2) 40 cc. of a solution containing 0.05 per cent KNO_3, 0.025 per cent $MgSO_4$, and 0.025 per cent K_2HPO_4, (3) 40 cc. of a solution twice as concentrated as 2, (4) 40 cc. of a 0.5 per cent solution of Difco yeast extract paste, and (5) 40 cc. of a 1 per cent solution of the paste.

After 200 days the cultures were opened and the termites present were examined and counted. They were then replaced in their respective culture bottles for further growth. Unfortunately 3 months later in transporting the cultures from Palo Alto, California, to Austin, Texas, the termites were killed by the heat and no further data on growth were obtained, nor could the final number, weight, or nitrogen content of the termites be accurately determined. However, the number and kind of termites present after 200 days and the weight of the wood disappearing after 290 days show a significant trend. These data are presented in Table X.

Superficial examination of burrows and termites visible in the culture at 280 days (before the death of the termites) indicated that both yeast extract cultures had surpassed the others. Culture 5 contained more eggs and young individuals than were present in any of the rest. The author is of the opinion that the weight of wood disappearing is a good index to the amount of growth of the termites at 290 days but since molds might partially account for the loss in weight this interpretation is open to question. No mold growths were macroscopically visible in the yeast extract and pure sawdust cultures but they were visible in the cultures with the added salts.

TABLE X. KINDS OF TERMITES AT THE END OF 200 DAYS

Culture Number and Substrate	Alates	Soldier 5th inst.	5th inst. Nymphs	4th	3rd	2nd	1st	Eggs	Total No. Term. at 200 Days	Wt. of Wood Disappeared after 290 Days
(1) Sawdust + H_2O	2	1	3	2	.....	2	1	.....	11	1.6 gm.
(2) Sawdust + 0.5% KNO_3, .025% $MgSO_4$ and .025% K_2HPO_4	2	.....	.....	5	3	7	1	1	18	2.2
(3) Sawdust + 0.1% KNO_3, .05% $MgSO_4$ and .05% K_2HPO_4	2	.....	.....	14	.....	3	1	.....	20	2.6
(4) Sawdust + 0.5% yeast extract	2	1	6	7	.....	.....	1	6	17	4.1
(5) Sawdust + 1.0% yeast extract	2	1	7	11	4	4	6	1	35	5.4

This experiment shows that nitrogen added to wood increases the rate of growth of the termites. The yeast extract appeared to be more favorable than the salt solution though exact comparisons can hardly be made.

In subsequent experiments using sawdust with added dried yeast, several colonies of *Z. angusticollis* containing as many as 100 individuals were obtained from a pair of alates within 8 months. The excellent growth in these cultures with added nitrogen is in striking contrast to the slow and uncertain growth that has always been encountered when sawdust alone was used as food.

II. The Nitrogen Content of Filter Paper and Cotton

Since filter paper and cotton have often been used in experiments on termite nutrition it has seemed of interest to determine the amounts of nitrogen in these materials. Several different samples of filter paper and cotton were analyzed. The results are presented in Table XI.

Table XI. Percentages of Nitrogen in Filter Paper and Cotton

Material	Sample 1	Sample 2
Filter paper:		
Whatman No. 1	0.0111	0.0108
Whatman No. 42	0.0128	0.0122
Whatman No. 41H	0.0064	0.0061
Whatman No. 43	0.0217	0.0220
Sargent No. 500	0.0101	0.0100
Carl Schleicher and Schüll No. 595	0.0333	0.0337
Cotton:		
Raw cotton	0.211	0.209
Absorbent cotton	0.0197	0.0200
Absorbent cotton, mercerized	0.0041	0.0050

Miss Hendee (1935) reports that the filter paper (Whatman's No. 42) which she used contained 0.05 per cent nitrogen. The manufacturers of Whatman filter paper inform us that there is a considerable variation in the nitrogen content. This is also indicated by the above figures. Inspection of Table XI shows that most of the filter papers analyzed have a nitrogen content below that of wood, although some of them contain as much nitrogen as is found in some woods. On the basis of nitrogen content it appears that most filter papers are inferior to wood as food for termites. However, if the amount of nitrogen is the factor limiting growth filter papers exceptionally high in nitrogen might be as suitable as woods low in nitrogen.

TABLE XII. GENERAL COMPARISON OF SIX CULTURES OF KALOTERMES

(1) Expt. No.	1	2	3	4	5	6
(2) Condition of termite colony in log when collected	Old colony, many individuals	Some termites in rotten wood, few in sound	Old colony, many individuals	Early stage of the colony, few termites	Same wood as 4	Same as 4
(3) Condition of wood	Angiosperm, quite rotten	Some rotten parts but mostly sound	Angiosperm, quite rotten	Angiosperm, quite sound	Same as 4	Same as 4
(4) Added source of N	None	None	None	None	Yeast extract containing 22 mg. N	$(NH_4)_2SO_4$ containing 8.5 mg. N.
(5) Duration of experiment	26 mos.	4 mos.	26 mos.	26 mos.	20 mos.	26 mos.
(6) Wet wt. termites, begin	144.7 mg.	130.3 mg.	144.7 mg.	140.5 mg.	138.0 mg.	134.7 mg.
(7) N in termites, begin	2.60 mg.		2.60 mg.	2.46 mg.	2.42 mg.	2.36 mg.
(8) No. and kind termites, end	2 subst. royalty 5 soldiers 78 nymphs 5 eggs	Dead	2 subst. royalty 5 soldiers 127 nymphs 36 eggs	2 subst. royalty 2 soldiers 59 nymphs 8 eggs	2 subst. royalty 5 soldiers 163 nymphs 45 eggs	2 subst. royalty 9 soldiers 151 nymphs 43 eggs
(9) Dry wt. termites, end	60.0 mg.		88.2 mg.	59.0 mg.	189 mg.	176.8 mg.
(10) N in termites, end	4.42 mg.		6.16 mg.	4.79 mg.	16.62 mg.	14.3 mg.
(11) Wt. wood, begin	24.0 gm.		24.2 gm.	23.9 gm.	23.9 gm.	23.9 gm.
(12) N in wood, begin, PERCENT N	46.6 mg. 0.194 percent	.167 percent	36.3 mg. 0.150 percent	80.4 mg. 0.336 percent	80.4 mg.	80.4 mg.
(13) Wt. mixed wood and pellets, end	17.552 gm.		15.994 gm.	16.803 gm.	7.792 gm.	14.359 gm.
(14) Wt. wood disappearing	6.073		7.772	6.618	14.966	9.017
(15) N in mixed wood and pellets, end	44.2 mg.		32.2 mg.	73.2 mg.	72.3 mg.	73.2 mg.
(16) Wt. separated pellets, end	0.375 gm.		0.434 gm.	0.480 gm.	0.842 gm.	0.524 gm.
(17) N in separated pellets, end	1.21 mg.		1.37 mg.	2.62 mg.	7.79 mg.	2.98 mg.
(18) Wt. wood eaten	14.4 gm.		13.1 gm.	15.0 gm.	23.9 gm.	19.6 gm.
(19) Percentage of consumed N assimilated	6.5 percent		18.1 percent	4.6 percent	13.9 percent	16.4 percent
(20) Total N, begin	49.2 mg.		38.9 mg.	82.9 mg.	104.8 mg.	91.26 mg.
(21) Total N, end	49.8 mg.		39.7 mg.	80.6 mg.	96.7 mg.	90.48 mg.

This may explain the equal suitability of the wood and filter paper used by Cleveland (1925) and Cook and Scott (1933). However, since these authors did not base their estimates of growth upon an increase in nitrogen it is possible that the increases observed were similar to those of cultures 5 and 6 in Table I and did not represent a nitrogen assimilation.

On the basis of nitrogen content raw cotton is a better food for termites than any of the filter papers and woods which were analyzed during the course of the present investigation. Cotton was used by Oshima (1919) in culturing *Coptotermes formosanus*.

III. Experiments on *Kalotermes*

In these experiments the procedure was to collect *Kalotermes* colonies and the wood in which they were found, to grind and thereby homogenize this wood to allow more accurate estimation of its nitrogen content, and then to culture some of the termites on weighed amounts of the sawdust. Four colonies of *Kalotermes snyderi* were collected from driftwood along the beach near Port Aransas, Texas. The wood was ground in a Wiley mill and then weighed out for blank and experimental portions. The cultures were moistened, covered with a close-fitting ground glass lid, and kept in a moist chamber at a temperature of about 20 degrees C. Twenty nymphs and one soldier were weighed out for each culture, and blank samples of termites were set aside. The results are summarized in Table XII.

The values in horizontal column 18 of Table XII were calculated after the amount of pellets in the wood-pellet mixture had been determined according to the formula already given. Knowing the amount of pellets mixed with the uneaten wood the amount of wood consumed could be determined. In horizontal column 19 the nitrogen assimilated and retained by the termites is expressed as a percentage of the total nitrogen in the eaten wood. In all experiments except number 2 the termites survived and showed a significant increase in numbers, weight, and nitrogen content. The failure of culture 2 was apparently not due to lack of nitrogen and was probably caused by the toxic substances often present in gymnosperms, particularly cypress, cedar, and juniper, which the wood of experiment 2 resembled.

In none of the cultures was there any indication of nitrogen fixation. These experiments were performed under more carefully controlled conditions than any of the others reported in this paper and with the exception of experiment 5 there is a very satisfactory agreement between initial and final nitrogen. In number 5 with the yeast extract there was a significant loss.

In experiments 1, 3, and 4 where no nitrogen was added to the wood the greatest increase of the termites occurred on the wood with the least nitrogen, namely, culture 3 with 0.150 per cent. Culture 1 with 0.194 per cent and culture 4 with 0.336 per cent showed about the same growth, but less than 3. These comparisons suggest that the absolute amount of nitrogen in the wood is not necessarily a criterion as to its value to the termites and it must be supposed that the nitrogenous materials differ either as to their nature or their accessibility. In connection with this latter factor it may be pointed out that 59 per cent of the ingested wood in experiment 3 was digested and metabolized, whereas in 1 and 4 only 42 and 44 per cent, respectively, disappeared. Since a smaller percentage of the wood could be used by the termites in experiments 1 and 4 they consumed more, eating 14.4 gm. and 15.0 gm., respectively, as against 13.1 gm. for experiment 3. The greater availability of the nitrogen in experiment 3 might be due to the fact that the increased digestion of other materials exposed more nitrogen to be utilized by the termite. In this connection it is interesting to speculate on the relative importance to termites of lignin-decomposing fungi as compared with fungi primarily attacking cellulose. It might be expected that the former would be more beneficial than the latter, since they would break down the lignin which is almost unattacked by the termite and in so doing expose increased amounts of nitrogen for the termites. This postulated exposure of wood nitrogen by the fungi cannot be looked upon as simply the penetration of the cell walls to expose the nitrogen in the cytoplasm. That function is performed by the mandibles of the termite which so comminute the wood that traces of cell structures can hardly be found in the contents of the alimentary tract. If the fungi exert any nitrogen-exposing action it must be through changes in the chemical composition of the wood, perhaps through assimilation of the nitrogen into the fungus body.

As in the experiments with *Zootermopsis*, addition of nitrogen to the wood greatly increased the growth of *Kalotermes* and the amount of nitrogen assimilated. The yeast extract and ammonium sulphate cannot be compared as to their relative suitability since the amount of nitrogen in the yeast extract was greater. However, if it be assumed that the nitrogen assimilated from wood in experiment 4 (2.33 mg.) was also assimilated from the wood in 5 then the additional nitrogen assimilated in 5 may be looked upon as coming from the yeast extract. This amounts to 11.9 mg. out of 22 mg. added. If the nitrogen lost in experiment 5 (8.1 mg.) came entirely from the yeast extract it would still leave 13.9 mg. available to the termites of which 11.9 mg. were assimilated.

Following the same reasoning with the ammonium sulphate culture we find that the increased nitrogen over experiment 4 is 9.6 mg. or about equal to the amount of nitrogen added. Since the termites are probably unable to absorb and utilize the ammonium sulphate directly it must be supposed that in this experiment the nitrogenous salt was utilized by fungi and that their action either made this nitrogen usable by the termites or increased the utility of that already in the wood.

The *Kalotermes* cultures give no evidence of any nitrogen fixation. The increase of nitrogen in the termites was in all cases greater than the difference between initial and final nitrogen. The nitrogen in the pellets was less than that in the wood eaten by the termites, indicating that the nitrogen used for growth was obtained from the wood. Since the termites in the natural colony had been feeding on similar wood it seems highly probably that there, too, the nitrogenous materials in the wood were used for growth.

IV. Experiments on *Reticulitermes*

The wood (*Pinus taeda*) eaten by colonies of *Reticulitermes claripennis* in the vicinity of Bastrop, Texas, was analyzed. The nitrogen content and specific gravity of sound wood and termite-infested wood were determined in a manner similar to that used with *Zootermopsis*. The results are summarized in Table XIII.

Table XIII. Specific Gravity and Nitrogen Content of Sound and Infested *Pinus taeda*

	Sound Sapwood	Sound Heartwood	Termite Wood
No. samples analyzed	10	8	14
Aver. mg. N per gm	0.584 ± 0.025	0.495 ± 0.026	0.967 ± 0.105
Range	0.42 — 0.84	0.31 — 0.68	0.36 — 2.15
Aver. specific gravity	0.510 ± 0.015	0.601 ± 0.023	0.420 ± 0.021
Range	0.39 — 0.63	0.49 — 0.76	0.22 — 0.65
Aver. mg. N per cc	0.293 ± 0.010	0.294 ± 0.017	0.371 ± 0.029
Range	0.23 — 0.37	0.21 — 0.44	0.21 — 0.78

These analyses agree with those obtained for *Zootermopsis*. The wood eaten by the termites contains on the average almost double the percentage of nitrogen observed in the sound wood and some of the individual samples show even higher concentrations. This increase is in part due to decomposition of the non-nitrogenous components of the wood but is in part an actual increase of nitrogen, presumably brought in from the soil by fungi.

A number of attempts were made to culture *Reticulitermes* starting with a pair of alates. Some of these alates when placed on moist sawdust (*P. taeda*) soon died, apparently due to toxic materials which gave a noticeable strong odor to the culture. When soil was placed on top of the sawdust the alates burrowed first in it and later in the sawdust and in some cultures produced a number of young. These colonies lived for two years but as very little wood had been used to start the colony they died for lack of food. To one of these cultures raw cotton was

added before the termites had died and they showed some additional growth. No quantitative data of any kind were obtained.

A few cultures started with sawdust to which a small amount of yeast extract had been added (final nitrogen content 0.093 per cent) survived for over a year and produced a number of young. In these cultures again only a small amount of wood was present.

These results with *Reticulitermes* are in agreement with those for *Zootermopsis* and it is probable that in nature the representatives of this genus also depend upon the activities of molds to supply them with suitable kinds and amounts of nitrogen.

DISCUSSION

The available data indicate that *Zootermopsis* is unable to make extensive growth on sound wood containing 0.03–0.06 per cent nitrogen. This failure is not due to deficiency in the carbohydrate portion of the diet since during periods of two years or more the termites retain their protozoa and are therefore able to use the cellulose. The limiting factor is probably connected in some way with the supply of nitrogen. Whatever the exact nature of the limiting factor it is eliminated when yeast extract or a nitrogenous salt is supplied or when nitrogen is brought in from the soil by fungi. The latter action seems to be a mechanism which is of importance in nature.

The experiments with *Kalotermes* do not permit any conclusions to be drawn as to the role of fungi in transporting nitrogen since no samples of the original woods were available for analysis. The woods which gave slow growth of *Kalotermes* contained significantly larger percentages of nitrogen than did the unsuccessful woods used with *Zootermopsis*. There were still limiting factors for *Kalotermes* however, since addition of nitrogenous materials greatly increased the rate of nitrogen assimilation.

The habit of fungus cultivation has been described in representatives of the *Termitidae* (Hegh, 1922), the most specialized family of termites. The discovery that fungi play a role in the nutrition of *Zootermopsis* of the primitive family, *Kalotermitidae*, suggests that a dependence upon fungi is a primitive feature in the Isoptera which has reached its greatest development in the fungus-growing species of the *Termitidae*. It might be expected that members of the family *Rhinotermitidae* would show an intermediate stage. The evidence thus far obtained indicates a similarity between *Zootermopsis* and *Reticulitermes* and the closer association of *Reticulitermes* with the soil, as indicated by its common name of subterranean termite, suggests that the accumulation of nitrogen from the latter may be of even greater importance than in *Zootermopsis*. Without more evidence this can be only a tentative hypothesis since the close association of the subterranean termites with soil could be explained in a number of other ways.

It seems highly probable that only certain fungi are concerned with the nitrogen nutrition of *Zootermopsis* since many of the wood-destroying fungi apparently do not bring significant amounts of nitrogen from the soil into the wood (Hungate, 1940). Also it is common to observe in a

heavily-infested termite region, as the Monterey peninsula, California, that not all of the dead and decaying logs are attacked by termites. The finding of Heath that occasional pairs of royalty are found with a large excavation and very few young again suggests that suitable conditions for termite growth are not everywhere present in nature.

The fact that only woods with additional nitrogen gave good growth of *Zootermopsis* in the present experiments cannot be construed as indicating that only such woods will be consumed by termites in nature. Where suitable nitrogen is available in a local area poor in cellulose the termites may use cellulose materials low in nitrogen from other regions. In the later stages of development of a colony in wood if the nitrogenous materials are exhausted the insects might continue using the wood for carbohydrate and consume other individuals for nitrogen. This would explain the cannibalism that is so commonly observed in laboratory cultures of *Zootermopsis*. Such cannibalism may be looked upon as an indication that the nitrogenous materials for growth are limited. It can also be regarded as an expression of the economy with which nitrogen is used since it permits certain members to continue growth, using nitrogen accumulated somewhat earlier by the colony and present in certain individuals. This corresponds to protein utilization during starvation in the individual. Hendee (1935) has concluded that cannibalism is a normal occurrence in natural termite colonies. It is evident that such cannibalism does not explain the primary method by which nitrogen is assimilated for termite growth but is a means by which nitrogen previously accumulated in some individuals is transferred to others.

The question whether the beneficial effects of fungi in the present experiments can be explained by a synthesis of necessary vitamins cannot be adequately answered without more specific information on the nature of the nitrogenous materials in the wood and on the food requirements of the termites. However, certain considerations suggest that the diet was not deficient in vitamins alone. The fact that the termites in the unsuccessful cultures existed in an apparently healthy condition for periods up to two years does not suggest disease due to vitamin deficiencies. The only type of factor which could be of importance would be one associated with growth. Such a factor could not be one concerned with the development and differentiation of the colony since growth of a few individuals and their modification into the soldier caste were observed in colonies showing no significant increase in total nitrogen.

It might be postulated that small amounts of necessary vitamins were available but that these were insufficient for growth of more than a few individuals. The low total nitrogen content of the wood suggests that a lack of sufficient vitamins is at least linked with a scarcity of other necessary nitrogenous materials and is not the only limiting factor. Fungi of many sorts were present in the cultures. They were either utilizing vitamins present in the wood or were able to synthesize their own. In either case it would seem that a certain supply of these necessary substances would be available to the termites.

Toxic materials in the wood cause the failure of many termite cultures but in most of these cases death occurs in a few days to a few weeks and it seems doubtful whether a slight but continuous toxicity would account for the failure to grow where cultures lived for some time.

In connection with the nitrogen economy of termites Leach and Granovsky (1938) postulated that utilization of termite nitrogenous wastes by the protozoa and of protozoan nitrogenous wastes by the termite may prevent loss of nitrogen. Cultures No. 5 and 6 of Table I showed an increase of weight but a loss in nitrogen during the 97 days of the experiment. These experiments were not complicated by cannibalism. They show that the termites are not able to retain all of their nitrogen. This is further indicated by the fact that an analysis of fresh pellets collected in the laboratory showed the presence of uric acid. Pellets with a nitrogen content of 0.18 per cent were found to contain 0.02 per cent uric acid when analyzed colorimetrically. This nitrogenous waste product was apparently not used by the protozoa. The most probable estimate of the nitrogen metabolism of the termite is that it requires proteins and other complex nitrogenous foods and metabolizes them, giving off waste products, at least some of which cannot be utilized by the protozoa. The presence of marked proteolytic activity (Hungate, 1938) in the mid-gut region of the termite is in agreement with this interpretation.

This leaves the question: What do the protozoa use in the way of nitrogen? If they cannot use the waste products of the termite and if the termite absorbs the products of protein digestion it would seem that the protozoa must be nitrogen-starved. The observations of Andrew and Light (1929) on division rates in termite protozoa support this conclusion since they report a small number of division stages in the protozoa of termites at all times except a few days after ecdysis. During this first period of the instar a "mitotic flare" indicates rapid growth which soon populates the hind-gut with its normal quota of protozoa. It would appear from this that suitable conditions for protozoan growth are present for a limited period following ecdysis. As a working hypothesis it may be suggested that during a short period following the molt, there are present the nitrogenous materials necessary for protozoan growth. These materials might be termite metabolic products accumulating before and during ecdysis and excreted into the hind-gut soon after the molt. Elucidation of this problem must await further knowledge of the nitrogen metabolism of the termite and the protozoa but it is interesting to speculate on the possibility that these organisms are symbiotically linked not only through their carbohydrate metabolism but also in their transformations of nitrogen.

SUMMARY

Many experiments using sound pine wood as food for *Zootermopsis* have failed to give significant growth and increase of nitrogen of the termites. Experiments using decayed pine wood give variable results. In some cases successful colonies are

obtained whereas in others the termites grow no better than on sound wood. In the successful colonies it was found that there was a very great increase in the nitrogen of the wood at the expense of nitrogen in the soil, presumably due to fungus action. Similar increases in wood nitrogen were not found in unsuccessful colonies.

No evidence of nitrogen fixation in laboratory termite colonies was observed.

Filter paper was shown to contain in some cases as much nitrogen as some woods.

Addition of nitrogen sources to sound wood markedly increased the growth of *Zootermopsis* and *Kalotermes*.

Analyses of the wood of natural colonies of termites and comparisons with sound wood show that the concentration of nitrogen in the infested wood is greater than can be accounted for by decomposition of carbohydrate materials. The additional nitrogen is probably brought in from the soil by fungi. There is evidence that not all fungi are equally effective in promoting termite growth.

Calculations show that the termites assimilate as much as fifty per cent of the ingested nitrogen.

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AGNOPHILOGENIA MONOTIS, NEW GENUS AND SPECIES OF DRAGONFLY FROM HUMID NORTHWESTERN ECUADOR

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In April of this year I received from the collector, Mr. David Laddey, Esq., a few envelopes of dragonflies collected at La Lorena, Santa Domingo de Los Colorados, Prov. Pichincha, Ecuador. This is at a low elevation, 550 meters, in the humid northwestern corner of Ecuador. It is an extension into the northwestern corner of Ecuador of the southernmost tip of the very humid area that forms the west coast of Colombia. In Ecuador at least, it is very malarious. It rains so nearly continuously that professional collectors cannot make even pin money. It is the occasional new or inexperienced collector that ventures into Santo Domingo de Los Colorados and who returns with prizes but not in sufficient quantity to get his accounts out of the red. Among fifty specimens or less brought out by Laddey were a new Perilestes (one male), a new Miocora (one male), the new genus to be described *postea* (one female), a short series of males of Calvert's *Neocordulia longipollex* known previously from one male and a small series of what is probably a new Heteragrion. In the two weeks' trip the collector found only a few hours of sunshine. This particular coastal strip from Panama south to northwestern Ecuador is so wet and malarial that its fauna is one of the least known in South America. It is full of prizes. It awaits the collector immune to its diseases and depressing weather.

The single female described appears to be a large relative of Philogenia. The main generic difference from the latter is the presence of three antenodal crossveins.

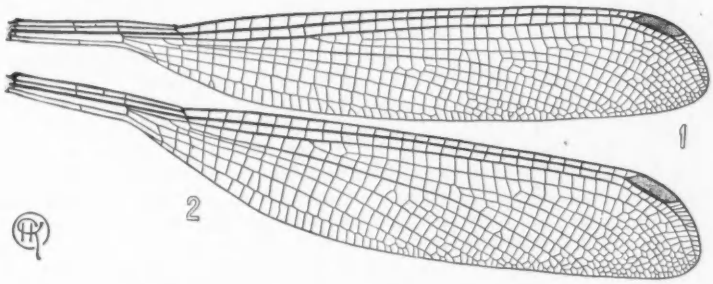
Agnophilogenia = pure Philogenia.

Agnophilogenia, new genus

(Figs. 1 and 2)

Wings hyaline, long and narrow, width six times into length with front and hind edges parallel in the outer half except for the rounded

apex of front edge: petioled to middle level of quadrangle. Three antenodals in the costal space, the third being midway between the first and last, which two are those normal to other Megapodagrioninae. The extra or third antenodal is lacking in the subcostal space. Stigma long, subtending 5 R_1 cells; with slightly oblique ends which are roughly parallel. Ac just beyond level of antenodal one. Quadrangle moderately narrow with oblique apical side and nearly parallel front and hind sides; basal side about two times in apical side, six in anterior and seven or eight times in posterior side. Two post-quadrangular cells before level of subnodus. Thirty postnodals in fore wing, 28 in hind wing. Main veins moderately smooth but not conspicuously so as in Heteragrion. Rs arises at subnodus (deformed in fig. 1): M_3 arises 1½ cells before subnodus: M_{1a} arises at postnodal 10 in fore wing, at



Figs. 1 and 2. Right wings of the female holotype of *Agnophilogenia monotis*, a new genus of Megapodagrionine dragonfly.

9 in hind wing: M_2 at 7 in fore and hind wings. Six well developed extra sectors, 2 between M_{1a} and M_2, 2 between M_2 and Rs and 2 between Rs and M_3. Four to six other less well developed extra sectors 4–8 cells long occur in the same apical region.

Other structural characters, some of which are possibly of generic value, are:

Legs with very long, slender spines (figs. 8–10), some more than four times as long as the adjacent interspaces; apex of hind femur reaching beyond middle of abdominal segment 2 (female). Frons rounded (fig. 4). Antenna when extended ectad with apex of its flagella reaching slightly beyond outer contour of the compound eye; two free basal segments, the second twice as long as the first. Labium with a rectangular apical notch. Prothorax with the usual simple Megapodagrionine form (figs. 3, 5 and 6). Mesostigmal lamina simple (fig. 11).

Ovipositor with apex on a level with the apices of the cerci. The latter thin and foliate, the longer cross-axis vertical. In view from side the ventral edge (fig. 7) is nearly straight (very slightly convex) while the dorsal edge rounds downward to a minute almost needle-like apex.

Color a pattern of the reddish browns, black, tans and creams of a Philogenia.

Genotype = *Agnophilogenia monotis* n. sp. described below.

Agnophilogenia monotis n. sp.
(Figs. 1–11)

Holotype, female. Abdomen 44 mm. long including apical abdominal appendages, hind wing 42 mm.

Labium with apical two-thirds including palps, black, basal third and maxillae rich brown. Labrum (fig. 4) very dark brown edged below with medium reddish brown. Clypeus with vertical anterior surface brown, the horizontal dorsal surface with its anterior half black shading into dark brown on the posterior half. Frons very dark brown shading into black. Antennae pale brown, especially on anterior surface, a touch of black at apex of each of the basal two segments. Vertex and genae dark brown shading into a black bar across occipital edge of top of head. A pale creamy dot at each end of the black occipital bar. Under surface of head of a clouded nondescript pale color (brownish gray?).

Prothorax (figs. 3, 5 and 6) in reddish brown and black; a dorsal midline black stripe, narrowed on the middle lobe to the area between the dorsolateral inflations, slightly widened on anterior lobe but widened behind to cover the posterior lobe except its outer angles and a pair of obscure dorsal pale spots on its anterior area. All coxae and legs uniformly reddish pale brown; spines darker red and apices of femora with a touch of dark brown.

Pterothorax (fig. 3) with mesepisternum a rich reddish brown, the middorsal and antealar keels edged with black. Mesepimeron and mesinfraepisternum black except for a narrow post humeral line cream colored which extends across the lower outer angle of mesepisternum to mesostigmal lamina. Metepisternum black with its anterior edge creamy and this pale area spreading out at top and bottom to cover the greater part of the dorsal and ventral ends of this sclerite. Its upper end shades into dull dark brown, its lower end into cream, the latter extended over the lower posterior angle of the mesinfraepisternum. Metepimeron and metinfraepisternum creamy, the upper edge of the latter black (an extension of the metepisternal black) while a large roughly triangular black spot covers the posterior half of the metepimeron. Ventral surface entirely pale creamy. Wing veins very dark brown as are the stigmas.

Abdomen black with paired Argia-like pale markings. Seg. 1 largely pale brown, edged posteriorly with black; seg. 2 black with a narrow lateral bar (fig. 3) pale. Seg. 3 with an anterior lateral blue oval spot (longitudinal axis vertical) which forms the anterior end of a

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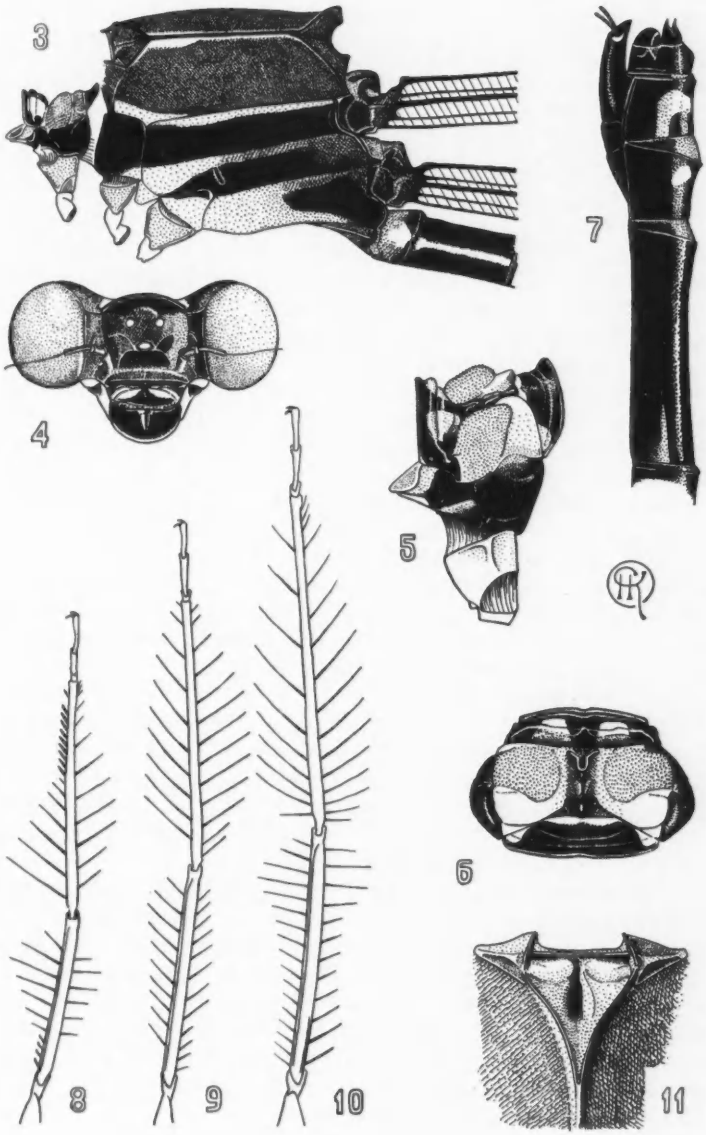
EXPLANATION OF FIGURES

Agnophilogenia monotis, female holotype. Fig. 3. Color pattern of thorax and abdominal segments 1 and 2. Fig. 4. Color pattern of head. 5 and 6. Color pattern and shape of prothorax. 7. Abdominal segments seven to ten. Figs. 8–10. Fore, middle and hind right legs. 11. Mesostigmal lamina.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lateral stripe of hair-like width and which reaches to last third of segment 3. Segs. 4–7 with anterior lateral pale spots (fig. 7) of the shape of the spot and stripe on seg. 3 but shortened to one-third or one-fourth of length of the segment. Segs. 8 and 9 with a pair of subapical dorsal oval spots: those on 9 connected across the middorsal line and at their anterior ends extended cephalad as a broad lateral stripe to the segment base. Seg. 10 and appendages black.

The structural characters have been given *antea* under the generic description.

Described from the single female mentioned at the beginning of this article, collected by David B. Laddey, March 8, 1941, at Lorena Pichincha, Ecuador, and now in the author's collection.

Agnophilogenia monotis = single female (of) pure Philogenia.

This female keys out in Munz to Trineuragrion. It keys out in Calvert's "Generic Characters and the species of Philogenia Selys," 1924, if we ignore the three antenodals, to the female of *Philogenia cassandra* Hagen. Among the material examined by Calvert were two males of this species which had a third antenodal crossvein in one wing each. In the female described *antea* the third or extra antenodal in the right front wing is not complete. See our fig. 1. The coloration of the abdomen of our specimen fits rather closely that of some females of *cassandra* discussed by Calvert (pp. 25–26). The hind lobe of the thorax is similar to that in *cassandra* but with less pronounced square outer ends. When the male is discovered his characters may show this female to be merely a large three-antenodaled *cassandra*.

The differences are as follows: The abdomen in *cassandra* is 34.5–41 mm., average 36.3 mm., in the above female it is 44 mm. In *cassandra* postnodals in front wings are 21–26, average 23.7; hind wing 20–26, average 21.9. In the female described there are 30 in each front wing and 26 in one hind wing with 28 in the other hind wing.

Almost systematically in the subfamily of Megapodagrioninae any permanent change in the number of antenodals, in the number of Ac veins or in any other constant detail has been answered by Odonatists in the erection of a new genus. We recognize the closeness of Agnophilogenia to Philogenia, but if Agnophilogenia has consistently three antenodals and two antenodals are true for Philogenia with only sporadic exceptions, we believe, on the strength of taxonomic practice, a new generic name is valid for the species *monotis*.

Cassandra's prophecy is again without a believer.

THE LIFE HISTORY AND GROWTH OF PTERONARCYS PROTEUS NEWMAN

(Pteronarcidae: Plecoptera)

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The genus *Pteronarcys* was erected by *Newman* in 1838. In 1843 *Newport* noted that external gills were to be found on the adult and he expressed the opinion that *Pteronarcys* must be quite primitive, because external gills do not occur on the adults of other insects. *Miller*, 1939, studied the embryology of *Pteronarcys proteus* and concluded that the generalized development reflected "the natural affinity between the Plecoptera, Isoptera and Orthoptera." *Snodgrass* (1935) used *Pteronarcys* as an example of a morphologically primitive insect. Indeed, *Pteronarcys* is used in some laboratories as an introduction to the study of insect morphology.

Since the anatomy is relatively unspecialized, studies on *Pteronarcys* should provide a good basis of comparison with similar investigations in higher forms. The genus is widely distributed and may be found in abundance in almost any pure cold upland stream. The determent to further study of *Pteronarcys* has not been its unavailability, but lack of knowledge of its life history. The number of instars and the time of year when a given stage may be collected have not previously been recorded. The purpose of this paper is to supply these facts and to consider some aspects of growth in a member of this primitive genus.

Dr. Albert Miller (1939) has captured members of the last nymphal stage and successfully reared them to adults. Confined imagoes will mate, and consequently Miller was able to obtain numbers of eggs. Oviposition usually begins during the last week in May, and lasts about three weeks, although in some cases oviposition may extend through June. Miller placed the eggs in a trough of running lake water, simulating natural conditions, and found that the eggs did not hatch until April 1–12 of the following year (305–325 days). Diapause is apparently not obligatory since hatching may be forced by exposure to higher temperatures.

If, late in May, *Pteronarcys proteus* nymphs are collected from a stream, the early instars that have hatched the month before are captured. In addition, according to Miller, one would find three other "distinct size groups which do not intergrade." Next largest to the early instars would be individuals which are larger than a reared fourth instar, and which are presumably in their second year of growth. The next larger size is probably three years old and the largest, usually ready to transform to the adult, is four years old. These were my beliefs until the present study of collecting records and measurements of head-widths led me to conclude that the life cycle is generally only three years but may be four years.

All nymphal stages of *Pteronarcys proteus* were collected in Sunderland, Mass., from the brook leading into the town reservoir. The specimens were fixed in Bouin's, Allen's modification of Bouin's, or Kahle's fixatives. The width of the head, including the compound eyes, was deemed to be a reliable measurement, since it is not altered by the action of fixative. Measurements of head capsules of early instars, including the fifth, were made with the aid of a calibrated occular micrometer and a compound microscope. Measurements of the older instars were made with steel calipers while under observation through a dissecting microscope. The calipers were then read by means of the microscope, and by that method the reading could be accurately gauged to one tenth of a millimeter. Measurements of many of the younger instars were checked by means of the calibrated micrometer. Gonads of the older instars were stained with Grenacher's borax-carmine and mounted whole in balsam.[1]

There are twelve nymphal instars which have been determined both by means of head capsule measurements and by observation of the wing pads. Head-widths of the last three instars intergrade but do not overlap. Borderline individuals, however, can be assigned to the correct stadium after inspection of the wing pads, which possess a different contour in each instar.

There are not enough specimens of the first three instars to provide average measurements. Miller, however, records the head-width of the first and second instars as .45–.46 mm. and "about .58 mm." respectively. In a letter, he informs me that the head-width of the third instar is .67 mm. Both of my tabulated third instars are in the process of secreting new integuments. Since measurements seem to indicate that the old integument has been stretched, it is probably best not to use these specimens but to consider material in the resting stage of development. Miller's figures for the first and third instar will be used in later computations.

THE TABLE

A survey of the collection dates for each instar shows that, including the egg stage, both three and four year cycles are possible. The post

[1]The writer wishes to thank Jeannette and James R. L. Holdsworth for their aid in collecting *Pteronarcys proteus*. He is also indebted to Dr. F. M. Carpenter and to Dr. S. C. Reed for their interest in the preparation of this paper.

eclosion life history of faster growing individuals follows: The nymphs hatch in April and go through the first six instars in the following six months and overwinter as sixth or seventh instars. The following spring development is continued, and growth proceeds until the following November when the nymphs develop slowly, if at all, and remain overwinter as tenth, eleventh or twelfth instars. The record of captures shows that tenth and eleventh instars have been taken in March, and that these presumably become twelfth instars and adults in May and early June. Twelfth instars are not to be found in late June or during July. (No collecting was done in August.)

That a fourth instar has been found as late in the year as September indicates that some individuals may overwinter as fifth and sixth instars, and during the following spring and summer may develop no further than the ninth or tenth stage. The capture of an eleventh instar in June indicates either precocious development of a nymph going into the third year of its life, or the retarded growth of a nymph going into its fourth year. It is certain, however, that most nymphs complete their life cycle about two years after eclosion.

It is apparent from the table that there is much variation in head-width within an instar. Twelfth instars, however, fall into two distinct groups. Dissection and whole mounts of gonads show the difference is one of sex. The average female has a head-width 12.5 per cent greater than that of the average male. This is in agreement with the conclusion of *Harries* and *Henderson* (1938) who worked with several species of Cicadellidae, which have five nymphal stages. When sex could be determined in the fifth instar, the head-width of the females was greater than that of the males.

The sexual differentiation in the head-width of the twelfth instar nymphs of *Pteronarcys proteus* might be expected to carry over to the adult stage. Adult females, however, were not obtained. Measurements of the adult head capsules in *Pteronarcys californica*, however, fall into two classes. Of twenty-six females measured, the average head-width was 5.1 mm.; of twenty males, 4.4 mm. The percentage difference is 15.4 per cent.

Statistical analysis corroborates the division of the adults into two size groups. The difference in standard error, computed according to the method given by *Sinnott* and *Dunn* (1932, second edition) is $.67 \pm .0316$, which indicates two distinct classes in size. The same method of analysis applied to *Pteronarcys proteus* twelfth instars yields a difference in standard error of $.63 \pm .122$. Thus there can be no doubt that the twelfth instar may be subdivided into two head-width groups according to sex.

The size discrepancy in the head capsule in the ultimate instars of *Pteronarcys proteus* might be explained on the basis of an extra moult on the part of the females. Indeed, *Schoenemund* (1912), who studied the life history of *Perla cephalotes*, has recorded extra moults on the part of the females. The female nymph goes through thirty-three instars in three years, while the much smaller male passes through fewer instars. But *Samal* (1923), who worked on the life history of *Perla abdominalis* Burm., records the same number of moults for each sex. Furthermore, if

TABLE OF COLLECTING AND GROWTH DATA FOR *Pteronarcys proteus* NEWMAN

Instar	Collection No.	Date of Collection	Head Width (mm.)	Average Measured Head-Width (mm.)	Computed Head-Width (mm.)	Progression Factor	Remarks
I	37	.....	.40	.46*	.471	.....	*Miller's measurement
II	38	.....	.54	.54	.582	1.173	Reared specimen
	103	May 19, 1940	.60*	.....	.....	.....	*About to moult
III	104	May 19, 1940	.70	.67*	.722	1.25	*Miller's measurement
	110	July 17, 1940	.79	.....	.....	.....	About to moult to fourth instar
IV	112	Sept. 17, 1940	.80	.855	.892	1.276	
	105	July 17, 1940	.87				
	108	July 17, 1940	.87				
	107	July 17, 1940	.87				
	119	July 17, 1940	.85				
	120	June 28, 1940	.87				
V	117	Sept. 17, 1940	1.10	1.08	1.105	1.258	
	125	Sept. 17, 1940	1.10				
	127	July 17, 1940	1.05				
	128	July 17, 1940	1.05				
	129	July 17, 1940	1.05				
VI	115	Sept. 17, 1940	1.28	1.36	1.366	1.26	
	116	Sept. 17, 1940	1.28				
	111	Sept. 17, 1940	1.44				
	114	Sept. 17, 1940	1.44				
	126	Sept. 17, 1940	1.30				
	130	Sept. 17, 1940	1.37				
	131	Sept. 17, 1940	1.37				
	132	Sept. 17, 1940	1.37				
VII	30	Jan. 1, 1940	1.64	1.65	1.690	1.21	
	33	Jan. 1, 1940	1.53				
	46	Mar. 30, 1940	1.60				
	47	Mar. 30, 1940	1.80				
	52	Mar. 30, 1940	1.70				
	122	June 16, 1940	1.70				
VIII	48	Mar. 30, 1940	2.10	2.12	2.090	1.278	
	54	Mar. 30, 1940	2.00				
	56	Mar. 30, 1940	.20				
	57	Mar. 30, 1940	2.10				
	13	Nov. 28, 1939	2.20				
IX	28	Dec. 9, 1939	.8	2.66	2.586	1.256	
	94	May 19, 1940	2.85				
	80	June 28, 1940	2.6				
	58	Mar. 30, 1940	2.45				
	45	Mar. 30, 1940	2.60				

TABLE OF COLLECTING AND GROWTH DATA FOR *Pteronarcys proteus* NEWMAN
(Continued)

Instar	Collection No.	Date of Collection	Head Width (mm.)	Average Measured Head-Width (mm.)	Computed Head-Width (mm.)	Progression Factor	Remarks
X ♀	27	Dec. 9, 1939	3.24	3.22	3.199	1.21	
	32	Dec. 9, 1939	3.40				
	50	Mar. 30, 1940	3.12				
	29	Dec. 9, 1939	3.15				
	53	Mar. 30, 1940	3.00				
	76	June 28, 1940	3.40				
	82	May 19, 1940	3.30				
	83	May 19, 1940	3.30				
	—9	May 1938	3.30				
	—8	May 1938	3.30				
X ♂	44	Mar. 30, 1940	3.00	3.19			
	150	May 1940	3.15	.....	.....	.....	Newly moulted
	76	June 28, 1940	3.30				
	87	May 19, 1940	3.30				
	93	May 19, 1940	3.30				
	95	May 19, 1940	3.25				
	89	May 19, 1940	3.0				
XI ♀	69	Mar. 30, 1940	3.6	3.85	3.956	1.20	
	91	May 19, 1940	3.7				
	73	June 28, 1940	3.9				
	59	Mar. 30, 1940	3.85				
	—6	May 1938	4.2	.....	.....	.....	Newly moulted
	21	Nov. 28, 1939	4.1				
	60	Mar. 30, 1940	3.9				
XI ♂	14	June 1939	3.8				Newly moulted
XII ♀	85	May 19, 1940	5.0	5.15	.....	1.33	Early metamorphosis
	86	May 19, 1940	5.0	.....	.....	.....	Late metamorphosis
	71	May 19, 1940	4.9	.....	.....	.....	Early metamorphosis
	72	May 19, 1940	4.9	.....	.....	.....	Early metamorphosis
	24	.....	5.6	.....	.....	.....	Ovarioles small; no deposition of yolk
	—1	May 1938	5.0				
	—2	May 1938	5.0				
	—3	May 1938	5.3				
	3	May 1938	5.5				
XII ♂	—10	May 1938	4.7	4.52	.....	1.185	
	—11	May 1938	4.7				
	88	May 19, 1940	4.2	.....	.....	.....	Late metamorphosis
	31	Dec. 9, 1939	4.3				
	66	Late Apr. 1940	4.7	.....	.....	.....	Early metamorphosis
	70	Late Apr. 1940	4.4				
	—4	May 1938	4.5	.....	.....	.....	Adult integument nearly complete
	—5	May 1938	4.6	.....	.....	.....	Adult integument nearly complete
	49	Mar. 1940	4.4				
	—7	May 1938	4.7				

the female of *Pteronarcys proteus* did pass through an additional instar, we would expect to find female nymphs comparable in head-width (4.52) to twelfth instar males, but females of this size are not found.

Whether or not the sexual size differentiation occurs as early as the eleventh instar was impossible to determine because of the paucity of male nymphs. Individuals of the tenth instar vary in head-width from 3.0 mm. to 3.4 mm., yet dissections show conclusively that in this instar there is no correlation between head size and sex.

If, when one considers the life history as a whole, the head-width increases geometrically, it should be indicated by a constant growth ratio between instars. If the progression factor (growth ratio) is a constant, then a straight line should result from plotting the average

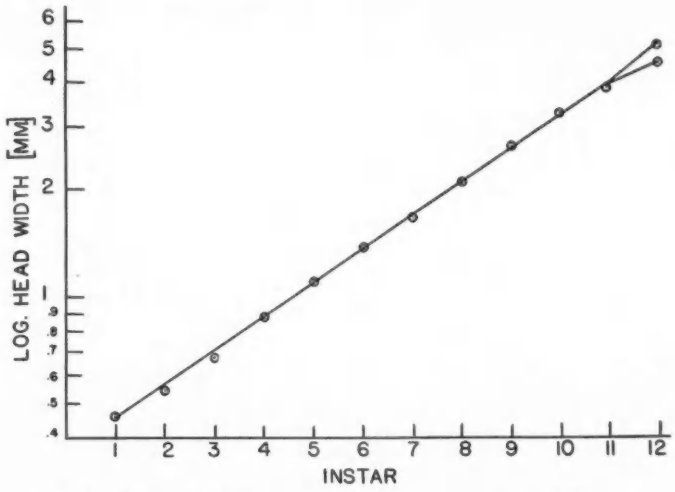

Fig. 1. Graph to illustrate growth in *Pteronarcys proteus* Newman.

head-width for each instar (on the log scale of arithlog paper) against the instar. The equation for such a line is log $y = a + bx$, where y is the width of the head, x is the number of the instar, b is the log of the progression factor, and a is a constant. Using the first eleven instars of *Pteronarcys proteus*, the locus of points of the average measured head when plotted against the instar (as stated above) is a straight line. The first eleven instars have an average growth ratio of 1.237. The twelfth instar males have a growth ratio of but 1.185. Last stage female nymphs, however, have head-widths 12.5 per cent larger than the males of the same age. The average ultimate female nymph head-width is 5.13 mm. In other words the old female nymphs attain a greater head-width than they would have if the progression factor had remained 1.237.

Conclusions that may be drawn from a consideration of the graph are as follows: The growth curve for the first eleven instars is a straight line, but growth from the eleventh to twelfth instar proceeds differently as indicated by two different curves. The mechanism governing the sexual growth-difference is not known.

Bodenheimer (1933) has recorded a comparable sexual difference. He states that "the females of all Acrididae, Phasmidae and probably also Mantidae doubled their weight between the last moult and the oviposition period. The increase in weight of ovarioles accounts for but one third of the total increase so the preoviposition period is an additional developmental stage lacking in the males of this order." Whether or not this sexual difference in weight is reflected in a linear dimension. Bodenheimer does not say. *Woodruff* (1939), who worked with *Blatella germanica* L., notes that the females "are noticeably more robust of body than the males." He states that the head-width, pronotum width and lengths of meso- and metathoracic tibiae were perhaps slightly larger in females, but differences were not mathematically significant. But the very obvious increase in size (and presumably weight) in *Pteronarcys proteus* females takes place prior to the last moult and with a correlated increase in head-width. This also appears to be the case with the Cicadellidae investigated by Harries and Henderson.

Gaines and *Campbell* (1935), who used the corn ear worm *Heliothis obsoleta*, found that growth ratios were high in the early instars and progressively decreased during growth. Thus the relation of head-widths to instar could be better expressed by a second degree equation: $\log y = a + bx + cx^2$ where y and x have the same values previously stated and a, b and c are constants. This equation also describes the growth of the Japanese beetle (*Popillia aponica* Newman), according to *Ludwig* and *Abercrombie* (1940).

The following examples support the conjecture that the trend of growth in insect head capsules seems to be one of a progressively decreasing growth ratio from instar to instar as one approaches the higher orders. For example, in *Nemouria vallicularia* Wu, *Wu* (1923), there is no marked decrease, although no inquiry was made into the possibility of sexual differences. But in *Pteronarcys proteus* there is a certain decrease in growth ratio, illustrated by *males* of the twelfth instar but certainly not by the females. If the data given by Woodruff (1938, 1939) for *Blatella germanica* is used, and the log of the head-width at time of moulting is plotted against the number of the stadium, it is apparent that the growth ratio is nearly constant up to the last nymphal instar. But the growth ratio of the adult to the last nymphal moult in *both male and female* alike is less than the growth ratio between nymphal moults. The last step in the series is constituted by such holometabalous insects as the corn ear worm and the Japanese beetle, which illustrate the progressively decreasing growth factor.

To generalize on a growth trend with a small amount of supporting evidence is brash, yet such a trend is a possibility that I believe is worth further consideration.

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A CATALOGUE OF THE PLECOPTERA OF THE WORLD, by PETER WALTER CLAASSEN. Pages 1-235, 6 x 9 inches, paper bound. This is Memoir 232, Cornell University Agricultural Experiment Station. Published June, 1940, at CORNELL UNIVERSITY, Ithaca, New York.

This posthumous work is the background work Professor Claassen had to do in getting out his various papers on North American Plecoptera and especially his two volumes, one on adults, Needham and Claassen, A Monograph of the Plecoptera of America North of Mexico, 1925, and Claassen, Plecoptera Nymphs of America (North of Mexico), 1931. Such a study involved the acquisition of an extensive private library (with that of Professor Needham) and the cataloguing of world species merely to check off names and species limited to North America. The volume is a bibliography of the world literature (pp. 209-235), then a systematic catalogue which lists all the species mentioned in the literature (pp. 19-208). Pages 5-18 are a two-column index in six point type of all genera, subgenera and species with known synonyms in italics.

At its inception much work was done by Dr. C. F. Wu up to the time when he had to return to China. The material for 1937 and 1938 was added to the manuscript by Mrs. Evelyn S. Claassen assisted by Albert R. Mead. Professors Needham, Palm, Johannsen and others have helped to get the manuscript completed after Professor Claassen's untimely death.

Professor Claassen wrote his name broadly across the systematic work on American Plecoptera.—C. H. K.

THE UTILIZATION OF CERTAIN NITROGENOUS AND CARBOHYDRATE SUBSTANCES BY THE SOUTHERN ARMYWORM, PRODENIA ERIDANIA CRAM.

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Our present knowledge of the nutritional requirements of insects pertains chiefly to those forms, such as cockroaches and stored products insects, that can easily be fed prepared diets. Leaf-eating insects present a distinct problem because of the nature of their food and the difficulty of causing them to feed on anything but their specific host plant or plants in the natural condition. Some recent work has been done on the utilization of various constituents of green leaves by several lepidopterous larvae (Brown, 1930; Evans, 1938, 1939a, 1939b) and by a grasshopper (Brown, 1937b). The present work, conducted along these same lines, was an effort to determine what nutrient materials the experimental insect was getting from its leaf-food.

THE EXPERIMENTAL INSECT

The southern armyworm, a pest of truck crops in the southern states, is being used more and more for insecticide testing because of the ease with which it can be reared throughout the year under laboratory conditions. Several physiological investigations and observations on this insect have been published (Babers and Woke, 1937; Babers, 1938a, 1938b; Gross and Howland, 1940).

Waters (1937) has described the laboratory conditions under which the insects used in this investigation were reared on the cranberry bean (London Horticultural Variety). This variety yields abundant and uniform foliage when the plants are grown from seed in moist clean sand without the use of nutrient solutions. As food for the larvae, use was made only of the first large leaves, which develop in about 15 days from the food stored in the cotyledons.

BIOLOGICAL PROCEDURE

Comparative chemical analyses of the food-leaves and of the fecal matter or excrement produced from that food by the experimental animals should give a good indication of the actual food materials being

utilized and the extent of that utilization. To accomplish this it was necessary to know the quantity of food eaten and of the excrement corresponding to that quantity of food.

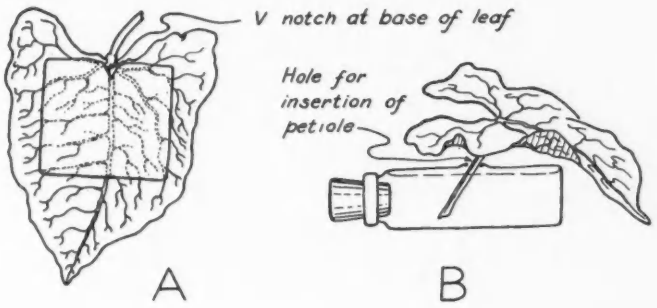
The leaves of the cranberry bean, being grown as they are under standard conditions of light, moisture and nutrition, are quite uniform in thickness. Therefore by determining dry weight per unit area of a sample of leaves and by feeding standard areas of known size it was possible to estimate dry weight of leaves eaten from the number of standard leaf areas completely consumed or from the dry weight of unconsumed portions of the standard areas. These standard areas and dry weight per unit-area were obtained as follows: A square celluloid template (fig. 1, A) was made of convenient size (13.79 sq. cm.) and, with this as the pattern, areas were cut from a large number of leaves from three different bean plots. These standard leaf areas were dried at 102 degrees C., weighed and the average dry weight of one leaf area, 22 mg., was calculated. Throughout this paper quantity of leaf tissue, excrement or their constituents is expressed on a dry weight basis.

In order to keep each standard leaf area fresh while the larvae were feeding on it, the stem of the leaf was left intact and thrust through a small hole previously blown in the side of a glass water vial. Whenever a partially consumed leaf area was to be dried and weighed, the stem and adjacent thickened region of the leaf area was cut away with a razor blade along the edges of a V notch on the base side of the celluloid template. This small region excluded from the standard leaf area by the V notch was protected from being eaten by covering it, as well as the leaf stem, with a bit of paraffin-treated cotton. The experimental larvae were confined to their food by placing them in an uncovered Petri dish surrounded by a wire screen collar surmounted by a greased celluloid ring to prevent the larvae from climbing out of the dish (fig. 1, C.).

As the water content of the bean leaves is very high, the excrement produced by the larvae is so moist that its immediate preservation is necessary to prevent chemical change. This was largely accomplished, it was believed, by frequent collecting and dropping of the fecal pellets directly into ethyl alcohol. The concentration of the alcohol had been previously adjusted to allow for the dilution of the excrement so that the final concentration would be 80 per cent or slightly higher.

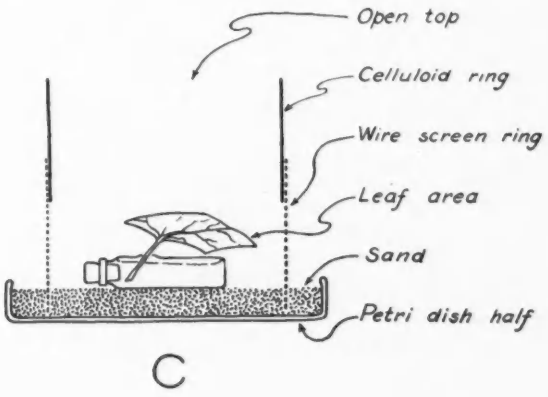
The larval development of the southern armyworm is usually completed in six instars. Only in the last two instars are the larvae large enough for accurate study of food consumption and utilization. It was therefore of interest to know what proportion of the food eaten during larval development is consumed by the 5th and 6th instars. An experiment was run with 30 larvae using the standard leaf area method. Sand was placed in the Petri dish halves so that the larvae, when mature, could pupate in it and would not befoul the leaf areas remaining. It was found that average food consumption by the first four instars was 4.4 mg. per larva and by the 5th and 6th instars 154.9 mg. per larva. Therefore the last two instars, which were used in the experiments to be described, consumed 97.2 per cent of the quantity of food required for larval development.

To obtain excrement for weighing and analysis in relation to food consumed, 60 larvae which had just molted into the 5th instar were selected from a group that had hatched from one egg mass and that had



CELLULOID TEMPLATE FOR CUTTING STANDARD LEAF AREAS

WATER VIAL FOR LEAVES



SCREEN AND CELLULOID COLLAR-CAGE

Fig. 1. Showing some pieces of equipment used in feeding experiments with the southern armyworm.

been reared through the first four instars under close observation. Record was kept of the number of standard leaf areas made available to them and the uneaten remnants of these areas were collected, dried

and weighed each day. At the end of the experiment the total figure was subtracted from the calculated weight of all the leaf areas used. The larvae were kept plentifully supplied with food at all times. No sand was placed in the Petri dishes in this experiment as it would have interfered with the collection of excrement.

To determine the gain in dry weight of the experimental larvae during this period, an equal number of new 5th instar larvae from the same batch and of the same fresh weight were killed, dried and weighed. This figure, representing the original dry weight of the experimental group was subtracted from that of the mature experimental larvae. Errors that could be attributed to food material in the gut were eliminated by weighing the larvae when their alimentary tracts were naturally empty. The larvae always evacuate their alimentary canals in the resting periods prior to molting, and it was found that the mature larvae also evacuated their intestines within a few hours after they ceased feeding. The latter condition could be recognized by the shrunken appearance of the larvae and by the semi-liquid condition of the last feces ejected.

CHEMICAL ANALYSES

Both the bean foliage and the excrement were analyzed for total soluble nitrogen, total insoluble nitrogen, amino acid nitrogen, amide nitrogen, nitrate nitrogen, ammonia nitrogen, reducing sugars, sucrose, and starch. They were extracted with 80 per cent ethyl alcohol in a Soxhlet extractor. The residue was dried at 102 degrees C., weighed and ground. The extract was made up to 1000 cc. volume with 80 per cent alcohol. The total weight of solids in the extract was determined by drying and weighing 100 cc. aliquots.

The Kjeldahl method, used for the determination of the total soluble nitrogen in the extract, was slightly modified to include nitrate N. Before digesting the samples by the conventional method, preliminary distillations into acid receiving flasks were run with Devarda's alloy which reduced the nitrate nitrogen to ammonia. The total insoluble nitrogen in the residue was determined by the unmodified Kjeldahl method. The per cent of protein was calculated by multiplying the per cent of insoluble nitrogen by the protein factor, 6.25.

Amino acid nitrogen was estimated with the van Slyke microapparatus.

Ammonia and amide nitrogen were determined with the van Slyke-Cullen urea apparatus. By this method the ammonia plus amide nitrogen was determined by first boiling the concentrated aliquots from the extract for an hour with sulphuric acid before the neutralizing with sodium hydroxide, addition of a saturated solution of potassium carbonate and aeration into acid receiving tubes in the urea apparatus. The ammonia nitrogen was found by omitting the acid boiling treatment and aerating simultaneously with the ammonia-amide tubes. To obtain amide nitrogen alone, the results of the ammonia determination were subtracted from those of the amide-ammonia determinations.

Nitrate nitrogen was found by adding Devarda's alloy to the liquid

residue from the aeration tubes of the amide-ammonia determination and distilling into acid receiving flasks.

Total reducing sugar determinations (expressed in terms of glucose) were made on lead acetate cleared aliquots of the extract. The unmodified Shaffer-Hartman method with iodimetric titration was used. For the determination of sucrose, aliquots of the cleared extract were hydrolyzed with invertase scales for 24 hours at laboratory temperature. Total sugars were then determined by the Shaffer-Hartman method and sucrose estimated by allowing for the total reducing sugars determined previously and applying the factor, .95.

The estimation of starch was made by the use of enzymatic action and the Shaffer-Hartman method for reducing sugars. Taka-diastase was added to a boiled suspension of the ground residue in water and the mixture allowed to incubate at room temperature for 24 hours. Toluene was used as a preservative in this determination as well as in the estimation of sucrose. After determination of the total reducing power, the quantity of starch was calculated after the manner of Thomas (1924).

DISCUSSION OF RESULTS

The results obtained on the quantity of food eaten in relation to the gain in weight and quantity of excrement produced are presented in Table I.

TABLE I. UTILIZATION OF BEAN FOLIAGE BY 60 SOUTHERN ARMYWORM LARVAE DURING THE FIFTH AND SIXTH INSTARS, IN GRAMS OF DRY WEIGHT

Weight of food eaten	.....	10.787
Increase in weight of larvae	3.618	.....
Weight of excrement produced	5.550	.....
Totals	9.168	10.787
Difference unaccounted for	1.619 g. or 15.0 per cent	

The difference unaccounted for may be attributed to loss through respiration and possibly to some mechanical loss of excrement.

$$\text{The per cent of utilization} = \frac{\text{weight of food utilized}}{\text{weight of food consumed}} \times 100$$

where the weight of food utilized is equal to the weight of food consumed (10.787 g.) minus the weight of excrement produced (5.5504 g.) or 5.237 g. The value obtained, 48.5 per cent, is surprisingly high considering that the ingested leaf matter passes through the gut in a very few hours. Other poikilothermic animals, such as fish, are known to have a high efficiency of utilization (McCay, 1938) which is largely attributed to the fact that it is not necessary for these animals to maintain a high body temperature with the resultant losses through respiration.

From the work of Evans (1939b), the per cents of utilization for several different species of lepidopterous larvae were calculated and are compared with that of the southern armyworm in Table II.

TABLE II. SHOWING COMPARISON OF THE PER CENTS OF UTILIZATION OF FOOD BY SEVERAL LEPIDOPTEROUS LARVAE, DRY WEIGHT BASIS

Species	Per Cent
Phalera bucephala (Evans)	35.0
Malacosoma neustria (Evans)	34.0
Aglais urticae (Evans)	25.7
Pieris brassicae (1) (Evans)	36.3
Pieris brassicae (2) (Evans)	39.1
Prodenia eridania (Author's data)	48.5

The insects used in securing the above data were all fed on different types of foliage: *P. bucephala* on hornbeam; *M. neustria* on willow; *A. urticae* on nettle; *P. brassicae* (1) on young cabbage leaves; *P. brassicae* (2) on old cabbage leaves; and *P. eridania* on cranberry bean seedlings.

TABLE III. SHOWING THE EFFICIENCY OF CONVERSION OF FOODSTUFF INTO BODY TISSUE BY THREE SPECIES OF INSECTS, DRY WEIGHT BASIS

Species	Dry Weight of Food Eaten	Gain in Dry Weight	Efficiency
	Grams	Grams	Per Cent
Blatella germanica (McCay)	9.3418	2.9587	31.6
	8.2832	2.5922	31.3
	8.5769	2.6835	31.3
Aglais urticae (Evans)	1.348	0.218	16.2
Prodenia eridania (Author's data)	10.787	3.618	33.5

It is difficult to compare the efficiency of utilization of several species of insects feeding on different plants. Evans' results with *P. brassicae* fed on young and old cabbage leaves show, however, that the efficiency of a species may well vary with the nutritive content of the food. It is curious that this species appears to utilize food more efficiently when fed old leaves which in general are less nutritive than young foliage.

McCay (1938) obtained some data on the conversion of foodstuffs into body tissue by the German roach (*Blattella germanica*) and Evans (1939b) has supplied similar information on *Aglais urticae* larvae. These results, together with those of the present writer on the southern armyworm, are given in Table III and are expressed as per cent efficiency derived by dividing the gain in dry weight of the insects by the dry weight of the food consumed.

Aglais urticae had the lowest per cent of utilization of the insects in Table II and would thus be expected to have low conversion efficiency. The high efficiency of conversion of *P. eridania*, almost identical to that for the roach, was surprising in view of the vast differences between the two types of insects and the nature of their food.

TABLE IV. COMPARATIVE ANALYSES AND EFFICIENCY OF UTILIZATION OF 10.787 G. OF LEAVES CONSUMED IN THE PRODUCTION OF 5.5504 G. OF EXCREMENT, DRY WEIGHT BASIS

	Foliage		Excrement		Efficiency of Utilization
	Per Cent	Mg.	Per Cent	Mg.	Per Cent
Total soluble N	2.12	228.7	5.38	299.1	.....
Amino acid N	1.16	125.1	0.51	28.2	77
Ammonia N	.....	None	0.27	15.0	.....
Amide N	0.25	26.9	0.18	10.3	62
Nitrate N	0.22	23.7	0.36	20.3	0
Reducing sugars	2.85	307.4	2.45	136.0	56
Sucrose	5.50	593.3	.....	trace	99
Total insol. N	4.52	486.8	0.77	42.9	91
Starch	2.37	255.8	4.91	272.5	0

The data on utilization of the constituents of cranberry bean leaves by the southern armyworm remain to be presented and discussed. The results of the chemical analyses, shown in Table IV, are expressed in terms of the total quantity of excrement (5.5504 g.) produced from the 10.787 g. of food eaten by 60 larvae during the 5th and 6th instars. The efficiency of utilization =

$$\frac{(\text{wt. of constituent in food eaten} - \text{wt. in excrement})}{\text{wt. of constituent in food eaten}} \times 100$$

There are two rather outstanding results shown in these data. It would appear that the southern armyworm is capable of utilizing the nitrogen from compounds other than protein and incapable of utilizing any starch. Although the total quantity of amino acid and amide nitrogen in the foliage is low relative to the insoluble or protein nitrogen, well over 50 per cent of the nitrogen in these compounds is utilized.

The failure to utilize starch would not seem unusual as several other lepidopterous larvae have been found incapable of using it (Evans, 1939b; Bottger, 1940; Swingle, 1928), but amylase has been reported to be present in the mid-guts of *P. eridania* larvae (Babers and Woke, 1937), and tests for this enzyme conducted by the author on boiled potato starch after the manner of Swingle (1928) were definitely positive. It was decided that the nature of the starch occurring in the bean foliage must be such as to resist the action of the amylase produced by the armyworm larvae.

It will be noticed that there appears to be a significant increase in the amount of starch in the excrement above that taken in with the leaves eaten. This was explained by the fact that there is a diurnal fluctuation of certain constituents of green leaves. According to Chibnall (1924) and other works cited by Miller (1938), sugars tend to build up during the day reaching a maximum sometime during the late afternoon. This is also true of proteins. Starch, on the other hand, is elaborated from the soluble sugars and does not reach its maximum concentration until midnight or later. The bean leaves analyzed in this study were taken from the greenhouse at 2:00 P. M. Thus, since the armyworms feed both day and night, there would be a tendency for them to ingest more starch and less protein and soluble sugars than would be indicated from the chemical analyses. Periodical collection and preservation of foliage for analysis throughout a 24-hour period would have produced a much more accurate figure of the average composition of these leaves.

Both reducing sugars and sucrose were utilized to an extent well over 50 per cent and insoluble or protein nitrogen to the extent of 91 per cent. Xanthoproteic tests for protein in the extracted residue of the excrement were strongly positive and the Biuret test was faintly positive on unextracted excrement. The true quantity of protein eliminated with the feces cannot be estimated accurately from these data owing to the probable presence of some insoluble nitrogenous metabolites in the extracted residue of the excrement. This conclusion was based partially on results of studies in mamalian physiology and may or may not apply here. According to various workers (Lusk, 1928) the nitrogen content of human, dog and other higher animal feces is due almost entirely to nitrogenous secretions from the intestines and to the bodies and products of myriad bacteria.

Owing to the high water content of the bean leaves (89 per cent) fed to the armyworms, a considerable quantity of nitrogenous compounds, including some uric acid and urates, was undoubtedly excreted in solution. This would account for the marked increase in soluble nitrogen in the excrement. Excretion of some nitrogen in the form of ammonia would tend to substantiate this view.

A rather incomplete table was compiled from recent literature to show the relative extent of utilization of various compounds in green leaves by several phytophagous insects.

Concerning the ability of phytophagous insects to utilize nitrogenous compounds other than protein very little seems to be known. Evans (1939a) found that neither amino acid nor amide nitrogen were utilized

by *P. bucephala* whereas the author found both these substances used to the extent of over 50 per cent by *P. eridania*. In general, however, the southern armyworm, as well as the other species listed in Table V, derive the largest share of their nourishment from protein and the simple sugars.

TABLE V. UTILIZATION OF VARIOUS LEAF CONSTITUENTS BY SEVERAL SPECIES OF PHYTOPHAGOUS INSECTS

Substance	Phalera bucephala (Evans)	Melanoplus bivittatus (Brown, A.W.A.)	Malacosoma neustria	Aglais urticae (Evans)	Pieris brassicae (Evans)	Automeris io (Brown, F. M.)	Pyrausta nubialis (Bottger)	Prodenia eridania (Author)
Protein	‡	‡	‡	‡	‡	⊕	⊕	‡
Amino N	△	△?	⊕	⊕	⊕	⊕	⊕	‡
Amide N	△	⊕	⊕	⊕	⊕	⊕	⊕	‡
Nitrate N	⊕	⊕	⊕	⊕	⊕	⊕	⊕	△
*Glucose	‡	‡	‡	†	‡	‡	⊕	‡
Sucrose	‡	⊕	‡	‡	‡	‡	⊕	‡
Starch	△	†	†	△?	△	△	△	△
Cellulose	△	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Other polysaccharides	△	† or △?	⊕	⊕	⊕	△	⊕	⊕
Fat	‡	⊕	†	‡	⊕	⊕	⊕	⊕

* Reducing sugars in terms of glucose.
† Utilization less than 50%.
‡ Utilization more than 50%.
△ Not utilized.
⊕ No data.
? Questionable.

SUMMARY

1. A method is described whereby known quantities of bean leaves, raised under standard conditions of light, moisture and nutrition, could be fed to 5th and 6th instar larvae of the southern armyworm.

2. Under laboratory conditions southern armyworm larvae of the last two instars (5th and 6th) were found to consume 97 per cent of the total amount of food eaten during larval development.

3. On dry weight basis, 10.787 g. of food eaten by 60 larvae during the last two instars produced 5.5504 g. of excrement with a gain in weight of larvae of 3.6183 g. This represents 48.5 per cent efficiency of utilization and 33.5 per cent efficiency of conversion of foodstuff into dry body weight.

4. Chemical analyses of the food-leaves and excrement of 5th and 6th instar southern armyworm larvae showed that this insect utilizes most of the protein, reducing sugars and sucrose in the leaves. They also use the nitrogen of naturally

occurring amino acids and amides, but do not use nitrate nitrogen. Starch is not utilized, although the presence of a starch-splitting enzyme was verified.

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BOOK NOTICES

RESPIRATORY ENZYMES, by A. ARNOLD, A. E. AXELROD, C. A. BAUMANN, J. BERGER, ROBERT H. BURRIS, W. B. CHRISTENSEN, P. P. COHEN, C. A. ELVEHJEM, EDGAR S. GORDON, M. J. JOHNSON, M. A. LIPTON, V. R. POTTER, H. A. SCHNEIDER, F. J. STARE, IRENE STARK and P. W. WILSON. 236 pages, 8¼ x 10¾ inches, paper. Third mimeoprinting. 1940. Published by the BURGESS PUBLISHING COMPANY, 426 South Sixth St., Minneapolis, Minn. Price, $3.25.

This book grew out of a biochemical seminar on respiratory enzymes at the University of Wisconsin. It consists of ten chapters arranged as follows: Historical Introduction; Dehydrogenases; The Oxidases, Catalase and Peroxidase; Coenzymes; Carriers—Cytochrome; Flavoproteins, Ascorbic Acid, Glutathione, and Adrenochrome; Inhibition of Dehydrogenases and Related Systems; Hydrogen Transport Systems; Oxidation-Reduction Potentials and Their Applications; Physical-Chemical Theory of Enzyme Reactions.

Each chapter was originally prepared or finally written by one or more of the biochemists named above. Each chapter carries its own table of contents and bibliography and is more or less independent of other chapters. Most chapters contain graphs, tables and structural formulae without consecutive numbering through the book. There is no index.

This reviewer would be a better entomologist if he were familiar with the contents of this book. If we wish to get more than a superficial knowledge of tissue respiration in insects and its bearing on the toxicology of insecticides, we should not neglect the extensive knowledge of respiratory enzymes gained in recent years by biochemists working on other organisms. With this book available, we cannot excuse our ignorance on the grounds that facts, theories, and methods are not at hand for our use. The question is whether we can find time and opportunity to apply the tools of biochemistry and other sciences. Entomologists who read this book will at least envisage a new and fertile field of research on insects. Insect toxicologists will be particularly interested in the chapter on inhibition of dehydrogenase and related systems, in which the action of cyanides, arsenites, sodium fluoride and other poisons is discussed.

Anyone who has Shepard's book on the chemistry and toxicology of insecticides needs no further description of the appearance and format of the present mimeoprinted book.—F. L. C.

INTRODUCTION TO PARASITOLOGY WITH SPECIAL REFERENCE TO THE PARASITES OF MAN, by ASA C. CHANDLER. xiii 698 pages, 309 figures. JOHN WILEY AND SONS, INC. Sixth Edition, 1940. Price, $5.00.

More than twenty years ago Dr. Chandler wrote a book on the relationship between man and his parasitic fauna, which was intended for use by the general public. This product was very readable and, unexpectedly, it was used in the classrooms of many schools. Its place as a standard textbook is proved by the fact that it is now in its sixth edition. This new revision is quite different from its predecessors in both content and organization, in that the common parasites of the domestic animals are briefly considered and the text is further systematized to meet the needs of the students. The many citations, particularly to recent literature, are a valuable addition for inquisitive students and teachers and greatly enhances the value to all for reference use. Keys are provided for the separation of the more common genera of the larger groups. The basic nature of the book has not been changed and it consists of the facts, principles, and problems of parasitology which are all presented in the delightful and fascinating style which has undoubtedly been largely responsible for the successful record this book has made.

Briefly stated, the subject matter is largely protozoa, worms, and arthropods. There is also a chapter on spirochaetes where syphilis receives special attention

and some other parasites of obscure systematic position are included. The section on arthropods consists of over one-third of the entire book and deals with mites, ticks, bedbugs, reduvids, biting and sucking lice, fleas, flies, and mosquitoes. Throughout other sections also, arthropods are frequently mentioned, especially the crustacea which serve as intermediate hosts for so many species of helminths. The information about these animals is largely biological; their life histories, ecology, control and eradication, and above all, relationships to disease causation are thoroughly discussed. Anatomy and classification receive scant attention.

This book is an excellent one to orient an individual to the broad field of Parasitology which has truly developed into the science about which Hall, Tyzzer, and others have spoken and written. There is no doubt that Chandler's "Parasitology" has had great influence in introducing and developing in students much of the enthusiasm which has resulted in the present national interest in this subject. It can be recommended to all biologists as informative, interesting, and necessary reading. The interrelationships between entomology and general parasitology form a large part of the book and should be of great interest to all entomologists desiring a modern and accurate account.—C. E. VENARD.

THE MOSQUITOES OF ARKANSAS, by STANLEY J. CARPENTER. 87 pages (15 pages of figures). ARKANSAS STATE BOARD OF HEALTH, Little Rock, Revised edition, 1941. Price, 50 cents.

Two years ago "The Mosquitoes of Arkansas" appeared in mimeographed form and a revised edition has now been printed as a bulletin. There are records of 42 species for the state and Carpenter has taken 34 of these species since 1937. Brief descriptions of the female and fourth stage larva of each species are given and keys for the separation of these species are included. There are many notes with particular reference to observations made within the state on the importance and habits of the various species. The text is supplemented with 15 pages of illustrations on life histories, equipment necessary for studying these insects, typical breeding sites, figures to facilitate the use of keys, and heads and terminal abdominal segments of selected species. Information on relationships between anopheline mosquitoes and malaria in Arkansas is scant but this is very likely due to the lack of data. The generalized discussion on mosquito control is good but in a bulletin of this type which will be widely used by private citizens and by municipal officials, it seems, to this reviewer, that more specific information on practical methods which such individuals could utilize would be exceedingly useful.—C. E. VENARD.

ATLAS OF THE SCALE INSECTS OF NORTH AMERICA, by GORDON FLOYD FERRIS. Series III, 269–384, 8.5 x 11.25 inches, 1941. Published by STANFORD UNIVERSITY PRESS, Stanford University, Calif. Price, bound, $7.75; unbound, $6.75.

We have before us the third volume of this magnificent work. With the completion of the next volume, Series IV, which the author hopes to have ready for the press by the end of this summer, the work on the family Diaspididae will be completed as far as existing collections and available material will permit. It will deal with somewhere between 25 and 50 more species, bringing the total in the family to something more than 325. There will remain not more than ten recorded species of this family from North America that will not have been seen in the course of the work. Series IV will therefore be rounded out by presenting a discussion of the morphology of the Diaspididae, the basis of classification, keys to the genera and species of North America, and other supplemental material. The publication of the next volume, Series IV, will see the original project about one-third completed.

Whether the work can be continued beyond Vol. IV (Series IV) or not will depend on finances. With the present slump of civilization toward a possible Dark Age the prospects do not look too bright. If completed the entire work will cover about 1000 species.

For those entomologists who have not seen this magnificent work we wish to point out that it is in quarto size, one plate of several, usually eight, drawings to each species. Facing the plate is a page of text covering Hosts and Distribution, Habit, Recognition Characters and Notes. The back of the plate is blank. The back of the text leaf is a title page.

Ferris had planned the work to be sold by the four-page folders as the sales unit. Thus the purchaser was expected to buy only for the species listed in his locality or otherwise of special interest to him. However, sales went almost entirely by bound volumes of the complete series. This meant that sales were limited largely to institutions and a few specialists.

The ANNALS has given this meritorious work a notice at every opportunity because we feel that it will be a long time in entomological history before again will be found combined in one person an artist, scale authority, and a physique of rugged health with ambition keen enough to put such another work across; also such a remarkable combination in an institution that permitted time on such research projects. If not completed now it may be a loss to our science over more than one coming generation. We hope that support will be found for Professor Ferris. We had hoped, as had Ferris in his plans, that the body of American entomologists could support it directly by purchase of enough folios or even Series volumes to pay its original cost.—C. H. K.

BASIC METHODS FOR EXPERIMENTS ON EGGS OF MARINE ANIMALS, by ERNEST EVERETT JUST. Pages x and 89. Loose leaf heavy leather binding, 6 x 9 inches. 1939. Published by BLAKISTON'S SON & CO., INC., 1012 Walnut St., Philadelphia. Price $1.25.

This is a purchase for our own set of works on microtechnique. It is written by the author of "The Biology of the Cell Surface," who is Professor of Zoology at Howard University. Professor Just is an old Woods Hole investigator who has spent many years studying the reactions of cell surfaces. Such are most easily studied on the free eggs of marine animals. Out of this long period of fine technique comes the above volume of directions for various types of experimental research.

The contents are: I. General Working Conditions, Precautions and Prerequisites; II. Normal Development; III. Methods for Handling Eggs and Sperm; IV. Some Methods for Preliminary Experimental Manipulations; V. Fixation; VI. Clearing and Imbedding; VII. Staining; Appendix.

Such a guide usually suggests to an enquiring mind methods that can be applied, perhaps with slight modification, to the eggs of aquatic insects. Method books are of the highest value in any biological laboratory.—C. H. K.

THE VIRUS: LIFE'S ENEMY, by KENNETH M. SMITH. 176 pp., 19 figs. 5.25 x 7.75 inches, 1940. Published as a volume of The Cambridge Library of Modern Science at the UNIVERSITY PRESS, Cambridge, England. In New York City by THE MACMILLAN COMPANY, 60 Fifth Ave. Price, $2.00.

This is a volume with no word of introduction. We have a vague feeling of loss, of an interesting subject detached and "in the air" as it were, when we search the volume for a few statements concerning the author and his connections with the science he depicts so interestingly. It is so skillfully written that it holds the reader's interest from cover to cover.

Kenneth Smith starts with the gradual development of biological theory which pulled epidemics and virus diseases out of the limbo of God-sent punishments and examples of spontaneous generation to the present era where causative agents can be demonstrated. This is Chapter I. Then he gives us a synoptic but interesting review of the methods used to filter out and determine the size of virus particles; then the methods of ultra-violet, X-ray and finally electron photography; the last a glimpse into the world of unbelievably minute objects. By such precise methods are determined the size and even the shapes and

crystalline (?) nature of viruses. This is Chapter II. Next is given the evidence pro and con as to whether a virus is living or nonliving. This is Chapter III. This closes Part I on The Nature of the Virus.

Part II, The Virus in Action, contains four subjects as follows: Chapter IV. How Viruses Get About; V. The Relationship between Viruses and the Insects Which Spread Them; VI. The Virus and the Living Cell; VII. Important Virus Diseases; VIII. Prevention and Control of Virus Diseases.

Chapter V, which discusses insect vectors, takes up such problems as: Does the virus undergo some change in the insect's body; Virus and leafhopper; Evidence on the nature of viruses; Why an insect as intermediary; Several viruses in one disease; Virus inheritance, and Difference in virus-transmitting power during an insect's lifetime.

As the transmission of virus diseases by insects has been shown to be of such vast economic importance from yellow fever to potato tip-burn, and in this volume the reader has a down-to-date review of the major facts concerning viruses, we feel that all economic entomologists could read this very well written work not only with intense interest but with personal profit. Because of its insignificant price, two dollars or the cost of four movies, we recommend it to all members of the Society.—C. H. K.

BIRD ISLANDS DOWN EAST, by HELEN GERE CRUICKSHANK with photographs by ALLAN D. CRUICKSHANK. Pages xii and 123, 6 x 8.5 inches. 1941. Published by THE MACMILLAN COMPANY, 60 Fifth Ave., New York City. Price $2.50.

About once in five years is produced an interesting non-technical work on some phase of American bird life. This is the current volume. Helen Gere Cruickshank gives the reader the vivid running account while her husband, Allan D. Cruickshank, contributes the equally vivid photographs. There are eleven chapters and forty-nine photographs. In spite of the unequal count the writer and the photographer continue side by side throughout the volume and arrive in the last chapter with thoughts on the beauties of nature and the difficulty of protecting its wild life. But all levity aside, for a man-and-wife book it is good. Each has contributed of the best.

The story is a running account of various trips through Maine fogs to the outermost islands along that fifteen hundred miles of rugged coast. These masses of rock are the bird islands, rookeries of the various sea birds which still remain after years of egg hunters, plume hunters and after the introduction into most of the Maine islands of rats and house cats. Thus the volume is a vivid description of one of the larger areas of still existent bird life which the Audubon Society is making every effort to preserve. The Society's work is merely mentioned but the Cruickshanks have been prominent in its work for a long time. The headquarters of the Audubon Society activities are on Hog Island in Muscongus Bay where the Society conducts a summer school mainly for leaders in nature study organizations. The school is in a bird and wild life preserve of several hundred acres and is so situated that from it many places of ornithological interest such as bird islands can be reached easily by boat.

Each chapter takes the reader through the fog to an outlying colony of a particular species of sea bird: Chapter III. Puffins; IV. Leach's Petrels; V. Cormorants; VI. Gulls and Guillemots; VII. Great Blue Herons; VIII. Osprays; IX. Banding the Herring Gulls; X. Arctic Terns; XI. Migration Time and Phalaropes.

We wish we had space to quote some of the interesting experiences of the authors, the nature and dumb habits of these primitive birds which can exist only where more recently evolved predators are excluded by rugged cliff or surrounding waters.

The author (or authors?) have given the inland bird lover an interesting picture of a type of bird life that few nature students have the privilege of seeing, hearing, smelling and feeling. The birds are a pleasing sight, the calls and swish of wings are thrilling, the guano and dead fish smell to high heaven while the observer itches from the bird lice that crawl over his person.

The skill of the writer is exhibited in recording the less pleasant aspects of sea bird colonies without disturbing the reader's gastric sensibilities. To anyone interested in birds a visit to a colony is an ever-to-be remembered event. The Cruickshanks have made it possible to take such a trip vicariously. It is a book that the reader begins and finishes before it is laid down.—C. H. K.

ORGANIZERS AND GENES, by C. H. WADDINGTON. Pages x and 160, 15 figs. 5.5 x 9 inches, 1940. Published in the "Cambridge Biological Studies" by THE CAMBRIDGE UNIVERSITY PRESS, Bentley House, Euston Road, London, N. W. 1 and MACMILLAN COMPANY, 60 Fifth Ave., New York City. Price, $3.50.

Among our recent purchases of books is the above very interesting attempt to co-ordinate the present theories in the science of genetics with the still rather nebulous theories of organizers in the realm of embryonic development. The theory of genetic control of adult characters has made great strides in recent years. But it deals with the distribution and redistribution of characters in individuals, species or populations and infers from such redistributions and from the behavior of chromosomes in the egg cell what may be the nature of the genetic mechanism within the egg. Embryology steps in and more or less ignoring genes in the egg, attempts to uncover the pattern of forces which organizes the material of the embryo. Waddington in this review essay makes a definite attempt to put together the few fragments of evidence which show relationships between the gene forces of the egg (also some forces in its cytoplasm) and those illy defined forces within the developing embryo which have been termed inductant forces, evocators, organizers, etc. In very recent years some interesting transplant work has been done on Drosophila embryos of known genetic composition. *In vitro* technique and microdissection have brought the two sciences into a united attack on such problems of development on this common and well explored ground. For the first time a philosophical and trained mind can outline a seemingly consistent general theory that helps explain complex happenings in both the genetic and embryological fields. The one is twin sister of the other. The two sciences are yet so young that genetic composition is best known in the Arthropoda (Drosophila) while induction and embryonic organization is best known in the Amphibia (frog, salamander, etc.). The author tries to stay with the vertebrates but at times cites invertebrates especially in the three chapters on genic action. In general the discussion swings around "induction."

The subjects discussed are: Chapter I. The Causal Analysis of Development; II. Organizers in Different Classes of Vertebrates; III. Analysis of Organizer Action; IV. Evocation; V. Competence; VI. Genic Action; VII. Temporal Course of Gene Reactions; VIII. Individuation; IX. Morphogenic Movements; X. Organizers and Growth; XI. Developmental Patterns; XII. The Theory of Organization.

The author writes at high speed and occasionally inserts sentences that a lesser mind has difficulty in interpreting. Figure out this formation of a groove: "When the invagination groove first appears, the cells which line it elongate in a direction at right angles to the surface, and at the same time their external surfaces decrease in area so that a depression is formed which is the origin of the groove" (p. 111).

The volume is of value in that it gives the embryologist and the geneticist a view each of his science from a standpoint which has much of the theory of the other. The two sciences cross in the development of the individual soma.

—C. H. K.

NOTICE TO AUTHORS OF ARTICLES WHICH HAVE APPEARED IN THE ANNALS

The Annals store room furnished by the Ohio State University is too crowded for further storage of the forty or fifty cases of cuts which have been used in printing the illustrations in the Annals. These are the property of the various authors who have paid for them. The Annals staff has stored and indexed these cuts to the year and issue, hoping they could be loaned for later use in other publications. About one such request for a cut or two is received in the course of two to five or more years. It is proposed to destroy them where the author is not enough interested to request them returned and to pay expressage for their return. The cuts of vols. I–X will be destroyed this fall, or we will be glad to give these cuts to each author requesting his, or to any responsible institution after authors have had the present opportunity to claim their own. We ask for any such blanket proposition.

We dislike very much to destroy the cuts but storage would cost from four to eight dollars per month which the Annals cannot afford to pay.—*The Managing Editor.*

ROYAL NORTON CHAPMAN